

Vol. 4 of 5 (Appx23382-32500)
No. 24-1098

**UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT**

BRITA LP,

Appellant,

v.

INTERNATIONAL TRADE COMMISSION,

Appellee,

ZERO TECHNOLOGIES, LLC, CULLIGAN INTERNATIONAL CO., VESTERGAARD
FRANDSEN INC., D/B/A LIFE STRAW, KAZ USA, INC., HELEN OF TROY LIMITED,

Intervenors.

Appeal from the United States International Trade Commission
in Investigation No. 337-TA-1294

NON-CONFIDENTIAL JOINT APPENDIX

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NOTE: Confidential information is indicated by green highlighting. The green shading in the table on Appx259 is not highlighting and does not indicate confidentiality. Markings of any other color are part of the document as filed at the Commission and do not indicate confidentiality.

The non-confidential version of this appendix redacts material filed under seal pursuant to the Commission's protective order. As required by Federal Circuit Rule 25.1(e)(1)(B), the table below notes the specific pages with redacted material in the non-confidential appendix and the general nature of that material.

Description of Redacted Material in Non-Confidential Appendix

Document	Pages	Description
Final Initial Determination on Violation of Section 337 and Recommended Determination on Remedy and Bond	Appx92, Appx107, Appx114-16, Appx121, Appx144, Appx148, Appx175-76, Appx178, Appx182, Appx185-86, Appx202, Appx204, Appx232-35, Appx351-62, Appx366-68, Appx370	Confidential product, technical, and financial information
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1 UNITED STATES INTERNATIONAL TRADE COMMISSION
2 Washington, D.C.
3 Before the Honorable MaryJoan McNamara
4 Administrative Law Judge
5

6 -----x
7 In the Matter of Investigation No.
8
9 CERTAIN HIGH-PERFORMANCE 337-TA-1294
10 GRAVITY-FED WATER FILTERS AND
11 PRODUCTS CONTAINING THE SAME
12 -----x

13
14
15 EVIDENTIARY HEARING
16 Thursday, October 13, 2022
17 Volume VI
18
19

20 The parties met via remote videoconferencing
21 pursuant to notice of the Administrative Law Judge at 9:30
22 a.m. Eastern.
23

24
25 Reported by: Linda S. Kinkade RDR CRR RMR RPR CSR

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23 ** Index appears at end of transcript **

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25

1 P R O C E E D I N G S

2 (In session at 9:30 a.m.)

3 JUDGE MCNAMARA: Good morning everyone. We are
4 here this morning on the continuation from August 23 of the
5 evidentiary hearing in Certain High Performance Gravity-Fed
6 Water Filters and Products Containing the Same.

7 So this morning or today we're just going to hear
8 from Dr. Benny Freeman and Dr. Gary Hatch.

9 Now there is only one patented issue here that
10 we're going to be discussing today, and that is the
11 8,167,141 patent, to which I will refer, and I'm sure
12 everyone else will as well, as the '141 patent.

13 So at this point what I would like to do is have
14 you, all of the lead attorneys, identify yourselves.

15 So, good morning, Mr. Ainsworth. You're here on
16 behalf of Brita LP, correct?

17 MR. AINSWORTH: I am, Your Honor. Good morning.

18 JUDGE MCNAMARA: Good morning. How are you
19 today?

20 MR. AINSWORTH: Wonderful. Thank you.

21 JUDGE MCNAMARA: Good. Would you like to
22 introduce your colleagues who will also be participants or
23 speaking today?

24 MR. AINSWORTH: Absolutely, Your Honor. In
25 addition to myself, my partner Ms. Everett will be speaking

1 today. She will be cross-examining Dr. Hatch.

2 JUDGE MCNAMARA: Very good. And I see that you
3 have other colleagues with you, Ms. Kim, Mr. Niemeier, and
4 Ms. Watt.

5 MR. AINSWORTH: That's correct, Your Honor. They
6 won't be on camera today, but Mr. Niemeier, Ms. Kim, and
7 Ms. Watt is here with us today as well as representatives
8 from Brita -- Mr. Napolitan is on right now -- and a few may
9 join later once it's later West Coast time.

10 JUDGE MCNAMARA: Sure. Very good.

11 Okay. Mr. Ainsworth, do you have an attorney
12 designated or designated attorney timekeeper for today?

13 MR. AINSWORTH: We do, Your Honor. That will be
14 Ms. Watt.

15 JUDGE MCNAMARA: Okay. Very good. And do you
16 have an attorney designated who is going to handle CBI or
17 confidential business information if we need to go off the
18 record?

19 MR. AINSWORTH: Yes, Your Honor. Ms. Watt will
20 be performing double duty today.

21 JUDGE MCNAMARA: Okay. Very good. Thank you,
22 Mr. Ainsworth.

23 Now, we also have as Respondents, and I'm going
24 to give their shortened names, the record will reflect the
25 corporate names, the PUR Respondents.

1 Good morning, Mr. Swain.

2 MR. LETCHINGER: Good morning, Judge McNamara.

3 This is -- uh-oh, we have an echo.

4 JUDGE MCNAMARA: Why don't you check your --

5 MR. LETCHINGER: Is this better?

6 JUDGE MCNAMARA: I'm not getting an echo.

7 MR. LETCHINGER: Well, it could just be in my
8 head.

9 This is John Letchinger, Your Honor. I represent
10 with Mr. Brandyberry the ZeroWater defendants. And I just
11 have an issue to raise with Your Honor, and then I'm going
12 to turn it over --

13 JUDGE MCNAMARA: No, let me finish, please, with
14 all the introductions, and let me go through what I need to
15 do in the beginning, and then, if you have an issue, I'll
16 ask for that for sure.

17 MR. LETCHINGER: Thank you, Your Honor.

18 JUDGE MCNAMARA: All right. Is Mr. Swain there?

19 MR. LETCHINGER: Yes, he is.

20 JUDGE MCNAMARA: All right. And then,
21 Mr. Letchinger, you've already identified yourself and
22 Mr. Brandyberry.

23 And then is Jeffrey Gargano there from LifeStraw?

24 MR. GARGANO: Yes, Your Honor.

25 JUDGE MCNAMARA: Okay. There you go. Now I can

1 see you.

2 Just a few things. And you also have, I think,
3 corporate attendees as well as other attendees. Would you
4 care to introduce any of the attendees, Mr. Letchinger?

5 MR. LETCHINGER: Yes, Your Honor. For the
6 ZeroWater defendants, John Griffith will be attending and
7 Mr. Doug Kellam will be attending for parts of today.

8 JUDGE MCNAMARA: Okay. Very good. And I see
9 that LifeStraw -- I don't see any PUR --

10 MR. LETCHINGER: Mr. Swain is on his way up to
11 the podium, Your Honor.

12 MR. SWAIN: Good morning, Your Honor. The third
13 tenor along with Mr. Gargano and Mr. Letchinger here. We're
14 still figuring out our audio setup in the room.

15 We will have a corporate representative later on
16 today, if she is not on right now, Ms. Melissa Silverstein,
17 VP and IP counsel for the PUR Respondents.

18 JUDGE MCNAMARA: I just saw their names. Thank
19 you very much.

20 When you initially came on, Mr. Swain, there was
21 some feedback there, but it seemed to dissipate as you spoke
22 a little longer.

23 So let me ask both sides. Mr. Ainsworth, how
24 long will today's proceedings last, if you know? Are you
25 taking the whole day?

1 MR. AINSWORTH: Your Honor, I sure hope not. I
2 don't know how long Mr. Hatch's direct examination is going
3 to go, so going first, that is Respondents' witness, I
4 suspect that Dr. Freeman, who is our rebuttal witness, may
5 be no more than two hours in terms of direct, but it kind of
6 depends on what we hear from Dr. Hatch.

7 JUDGE MCNAMARA: Okay. Very good. All right.

8 So let me see. Make sure, if you would, please,
9 that -- well, at the end of today we'll admit into evidence
10 the records. You will be sent, each party will be sent Box
11 links by Ms. Muhammad, who is with me this morning, along
12 with my attorneys who support me, Jae Lee and Anita Alanko.

13 I'm trying to do something a little different.
14 If we go most of the day, we'll certainly take a lunch
15 break. We will take a break in the morning. What I'm going
16 to try to do is take five-minute breaks every hour on the
17 half hour since we started at 9:30. It's just something
18 that I'm trying to do to help all of us at this point. But,
19 in any event, so that's where we are.

20 Now I'd be happy to entertain at this point an
21 issue that you raised, Mr. Letchinger.

22 MR. LETCHINGER: Your Honor, I'm sorry, our audio
23 cut out when you were speaking.

24 JUDGE MCNAMARA: All right. You started to
25 mention earlier that you have an issue that you would like

1 to raise.

2 MR. LETCHINGER: I do have an issue, Your Honor,
3 and thank you very much.

4 Your Honor, the issue we want to raise ultimately
5 relates to EDIS 778985, and for background, Your Honor, if
6 you recall, which is crazy because it was two months ago, at
7 the conclusion of Mr. Nishijima's testimony on behalf of
8 Brita, when he was discussing testing of the Brita legacy
9 filter, you asked counsel for Brita to go back and look to
10 see if they could find any other filters for testing
11 purposes that could have been tested when Mr. Nishijima had
12 stopped his testing of the one filter that Your Honor had
13 ordered us to provide back to Brita. And Mr. Ainsworth did
14 submit a declaration, that's the EDIS number I just
15 provided, and there were two declarations. One was on a
16 different topic and the other was in response to
17 Your Honor's order. And it's the declaration of Joseph
18 McShane.

19 And the concern we have, Your Honor, is, to put
20 it mildly, our read of the declaration is that it's a very
21 carefully worded declaration and specifically looking at
22 paragraph 5 and the chart that follows.

23 It reads, in the table below I identify the
24 samples that we located from the 1998 to 2000 time frame.
25 And I don't see anything in the record, Your Honor, where

1 you limited the charts to these couple of years.

2 And what's particularly troubling to Respondents
3 is there's seven or eight years prior to when the patent
4 application was filed when testing was presumably happening
5 that Brita has not provided an answer to Your Honor. And we
6 think this is an important issue. It was obviously an
7 important issue to Your Honor. And we would just ask for
8 clarification on that.

9 JUDGE MCNAMARA: What clarification are you
10 seeking?

11 MR. LETCHINGER: Whether they were able --

12 JUDGE MCNAMARA: You have to be precise.

13 MR. LETCHINGER: Whether they did search for
14 filters that existed from the 2001 to 2008 period that could
15 have been tested.

16 JUDGE MCNAMARA: Mr. Ainsworth, do you know the
17 answer to that?

18 MR. AINSWORTH: I do know the answer, Your Honor.
19 If I could respond to Mr. Letchinger's inquiry first.

20 Your Honor asked us to search for -- whether we
21 had the same filters that could have been tested for
22 comparison purposes, and the filter that was provided to us
23 was a 1999 Brita legacy filter, and that's what we searched
24 for. And we answered in the affirmative that we had those
25 filters.

1 We believe we answered Your Honor's question. As
2 you know, Your Honor, there has been a dispute over whether
3 Brita legacy filters from this entire time period are all
4 the same. We took the position that they were not. They
5 filed a motion in limine to try and argue that we couldn't
6 argue those differences.

7 And we have always maintained that there was
8 differences in the filter in that time period. The same
9 filter, the one from '99, included information in the '98
10 and 2000 filter, and confirmed that, yes, we have some
11 filters in our possession. We feel we answered Your Honor's
12 question.

13 What's really interesting about this is, when we
14 had a meet-and-confer with Respondents back in -- during the
15 evidentiary hearing about this declaration, they told us it
16 was a yes or no declaration, that all Your Honor wanted to
17 no was, yes or no, do we have those filters.

18 Mr. Swain said that on the record on day 5 of
19 trial about the yes or no declaration from Brita. We
20 answered affirmatively. We answered truthfully. We
21 answered accurately.

22 I asked them, counsel for ZeroWater, on Monday,
23 when they first raised this issue with us two days ago or a
24 week ago, why is it even relevant now. We answered the
25 question. You briefed this issue in the post-hearing

1 briefing already. It's been five weeks. And they have not
2 raised any concerns about the scope or responsiveness of our
3 declaration.

4 And certainly if Your Honor wants more
5 information from Brita, I will absolutely get that for
6 Your Honor. But I think I answered your question. And this
7 complaint now is six weeks too late and not even relevant to
8 any of the issues left to be briefed in this case.

9 JUDGE MCNAMARA: Mr. Letchinger, do you have a
10 response to that?

11 MR. LETCHINGER: A very fundamental issue in the
12 case, the Brita legacy filter is one of the primary one or
13 two references. We were only able to locate a few. We
14 tested it. It FRAP'd. They have raised some challenges to
15 our testing.

16 They had the opportunity at Your Honor's
17 instruction to test the filter and they stopped in the
18 middle of it at instruction of counsel.

19 This filter is also reported in the patent as
20 prior art. And when Brita filed a correction to the patent
21 changing the FRAP numbers, the filter that was tested and
22 reported came in at 371, just a little bit over the FRAP,
23 and it was loaded with lead.

24 JUDGE MCNAMARA: Mr. Letchinger, you're
25 testifying. I've already read the briefs and that issue was

1 raised. My question is more precise, and I'm sorry for
2 interrupting, but you're testifying or you appear to be
3 testifying.

4 The narrower question is, why didn't you raise
5 this in the last five to six weeks?

6 MR. LETCHINGER: Your Honor, in all candor, in
7 preparing for trial, all the Respondents got together and we
8 looked at this more carefully, it really became clear to us
9 that there was a big hole here and it was an important issue
10 at trial.

11 And we're just concerned about what's going on
12 with this seven-year period and whether there are other
13 filters available.

14 JUDGE MCNAMARA: I think it's a little late now,
15 Mr. Letchinger. I think if this had been -- if the
16 Respondents were as concerned, and I'm sure they are, as you
17 say, this should have been raised much sooner after the
18 declaration was filed, and it wasn't.

19 So the record is what it is right now. That's
20 what we have to deal with. The issue of the prior art has
21 been well-briefed. It has been extensively briefed. So I
22 will have to see and read what the declaration says together
23 with all the other evidence and make a decision based on
24 whether or not the parties have met their burdens of proof.

25 MR. LETCHINGER: Thank you, Your Honor.

1 JUDGE MCNAMARA: Based on the record as it exists
2 today and as it will exist at the end of today.

3 MR. LETCHINGER: Understood.

4 JUDGE MCNAMARA: But there were opportunities for
5 the Respondents to raise this and to brief it extensively or
6 to ask for this earlier and they did not. So that's where
7 we are. I've got the record I've got.

8 MR. LETCHINGER: Understood, Your Honor. Thank
9 you.

10 JUDGE MCNAMARA: But thank you. Okay.

11 So are you prepared, then, Mr. Letchinger, to
12 start? I think that -- I think it's Mr. Swain who is going
13 to be doing the examination, if I'm correct. I may not be.

14 MR. LETCHINGER: It will not be Mr. Swain, but it
15 will be PUR and I will make it a surprise and pass over the
16 mic so Dr. Hatch can testify.

17 JUDGE MCNAMARA: But who is going to be doing the
18 examination?

19 Good morning, Mr. Davison.

20 MR. DAVISON: Your Honor -- good morning,
21 Your Honor. I'm good. How are you doing?

22 JUDGE MCNAMARA: Very well. Thank you.

23 Mr. Hatch, it's good to see you. I hope you're
24 feeling much better.

25 THE WITNESS: Oh, thank you. I definitely am.

1 JUDGE MCNAMARA: Good. Glad to hear that. All
2 right. Would you kindly raise your right hand.

3 GARY HATCH,
4 having been first duly sworn and/or affirmed
5 on his oath, was thereafter examined and testified as
6 follows:

7 JUDGE MCNAMARA: Please state your full name.

8 THE WITNESS: Gary Linn Hatch.

9 JUDGE MCNAMARA: Thank you very much. And who is
10 going to be conducting the cross-examination for Brita?

11 MS. EVERETT: Good morning, Your Honor. This is
12 Uma Everett. I will be cross-examining Dr. Hatch.

13 JUDGE MCNAMARA: Very good. Good morning.

14 All right. So the floor is yours, Mr. Davison.
15 And I just want to make one thing clear, too. I would
16 really appreciate it if, when the witnesses are testifying,
17 when they give their opinion/conclusion, that you are truly
18 exploring and providing the rationale and the underlying
19 data testing as well with a discussion of the opinion so
20 that this is not simply conclusory testimony.

21 Just to advise you that I'm really looking for
22 some fulsome explanations of some of the disputes on
23 testing. And so I'm assuming that the opinions will not
24 only be provided but that there will be a clear explanation
25 and fulsome explanation of the underlying reasoning and

1 support for those opinions.

2 MR. DAVISON: Yes, Your Honor, that's our intent.

3 JUDGE MCNAMARA: Okay. Good. The floor is
4 yours, Mr. Davison.

5 MR. DAVISON: Thank you. Again, Tom Davison
6 speaking.

7 DIRECT EXAMINATION

8 BY MR. DAVISON:

9 Q. Dr. Hatch, will you please introduce yourself to
10 Judge McNamara?

11 A. Yes. My name is Gary Hatch. I live in McKinney,
12 Texas, which is just down the road a few miles. And I've
13 retired in 2009. Since then I started my own consulting
14 firm, Hatch Global Consulting Services. And I have over the
15 last few years provided advice to the point-of-use,
16 point-of-entry water treatment industry, as well as the
17 commercial beverage dispensing industry, and have since then
18 continued to work in that area and offering my advice in
19 developing water treatment equipment.

20 JUDGE MCNAMARA: Okay. May I ask one question --

21 MR. DAVISON: Before we get started --

22 JUDGE MCNAMARA: Mr. Davison, would you hold off
23 just a moment?

24 Dr. Hatch, are you testifying from the home
25 office?

1 THE WITNESS: I'm testifying here in Dallas,
2 Texas.

3 JUDGE MCNAMARA: Whose offices are you in?

4 THE WITNESS: Alston & Bird.

5 JUDGE MCNAMARA: Very good. I just wanted to
6 clarify that and know. Okay. Thank you.

7 Go ahead, Mr. Davison. Be careful and wait for
8 any objections or speaking. Thank you.

9 MR. DAVISON: Let me repeat the previous question
10 I had for you.

11 Q. Before we get started, is there anything you
12 would like to say to the Court?

13 A. Yes. I would certainly like to thank you, Judge,
14 Your Honor, in letting -- rearranging the testimony that I
15 was supposed to do in August. There was no way I could have
16 testified at that time since I came down with COVID, and I
17 really appreciate the effort from you, Your Honor, and the
18 opposing attorney and my counsel for rearranging the
19 testimony. I appreciate that very much.

20 JUDGE MCNAMARA: You are most welcome. Just as
21 long as you're well.

22 Q. Dr. Hatch, we know -- recently I had COVID -- if
23 you need a break today, let us know, and we'll ask Judge
24 McNamara for permission to take a break. Is that okay?

25 A. All right. Thank you.

1 JUDGE MCNAMARA: No worries on that one, anytime
2 you need one.

3 Q. Mr. Campos, can we have RX-949, please.

4 Dr. Hatch, do you recognize RX-949?

5 A. Yes, I do. That's my curriculum vitae.

6 Q. Did you work with counsel to prepare a series of
7 demonstratives to help you illustrate your testimony today?

8 A. Yes, I did.

9 Q. And did you create a demonstrative that
10 summarizes your education and work experience?

11 A. Yes, I did.

12 Q. Mr. Campos, can we please have RDX-8.2?

13 Dr. Hatch, can you briefly describe your
14 education and work experience?

15 A. Sure. I obtained a bachelor's and master's
16 degree in chemistry from Emporia State University in
17 Emporia, Kansas, and from there I went on to Kansas State
18 University where I obtained a Ph.D. in analytical and
19 organic chemistry.

20 My doctoral thesis was about the chemical and
21 disinfection properties of a iodine resin water
22 disinfectant. That process and that technology was adopted
23 later by NASA as use on spaceships for disinfecting
24 astronauts' drinking water. It also was commercialized into
25 a number of small-scale emergency water disinfection

1 devices.

2 And from there, my work experience, first job out
3 of grad school was with Aqua-Chem in Milwaukee, Wisconsin.
4 There I continued on working on developing additional and
5 different types of iodine resin water disinfectants. From
6 there I went on to a small company in California, NewTech
7 Company, that hired me to develop new filtration technology
8 for their point-of-use water filtration devices. That
9 technology employed fibrous media with activated carbon and
10 was successful in changing out their previous filter
11 technology.

12 From there I went on to a company back in
13 Wisconsin, Ametek Plymouth Products Division, and there I
14 worked on developing many different types of activated
15 carbon water filters. That division through a series of
16 acquisitions eventually ended up with Pentair Water, where I
17 worked as director of R&D of Pentair residential filtration.

18 And there I, again, worked on developing many
19 different types of activated carbon filters, specifically
20 carbon block filters, or drinking water treatment.

21 Q. So Dr. Hatch, have you been working with water
22 filtration for the last 49 years?

23 A. Yes, I have.

24 Q. And so I see on RDX-8.2 you have NSF
25 International listed. Can you remind me, what is NSF?

1 A. NSF, first of all, is not National Science
2 Foundation. It's completely different. NSF stands for
3 National Sanitation Foundation as established in 1943 to
4 initially test and certify food-handling equipment and to
5 make sure that all food-handling equipment that gets tested
6 and certified is easily sanitized and does not spread any
7 microorganisms to cause any illnesses.

8 Later in the late '70s they became involved in
9 drinking water treatment standards development, and which
10 eventually resulted in a series of what we call DWTU
11 standards for testing and certifying point-of-use,
12 point-of-entry drinking water treatment units.

13 Q. And so, Dr. Hatch, what is your involvement with
14 NSF?

15 A. Actually I became involved with NSF back in the
16 mid '80s on the -- and eventually became a member of their
17 Joint Committee, which oversees the development and revision
18 and improvement of the drinking water treatment unit
19 standards. And I've sat on and chaired many task groups
20 that in that role of improving the drinking water treatment
21 unit standards, and have done since, as I said, the mid '80s
22 and still currently are on task groups still doing that job.

23 Q. And so, Dr. Hatch, are you familiar with the 2007
24 version of the NSF 53 standard?

25 A. Yes, I am.

1 Q. And did you participate in the development of the
2 2007 NSF 53 standard?

3 A. Yes, I did. Actually I wrote the test protocol
4 for the first draft of the test protocol for the pH 8.5 lead
5 reduction standard and later sent that on to NSF for the
6 Joint Committee to further amend, slightly amend, and then
7 they voted to accept that as the pH 8.5 lead reduction test
8 protocol in Standard 53.

9 Q. Thank you. Can we turn to RDX-8.3, please?

10 Dr. Hatch, can you remind me what is WQA?

11 A. WQA is the Water Quality Association. That's the
12 industry association for all members that are involved in
13 the point-of-use, point-of-entry drinking water and water
14 treatment industry.

15 Q. And have you won any awards from WQA?

16 A. Yes, I have. A number of years ago I won the
17 Award of Merit, which was an award for one participating on
18 their task groups and helping with their issues, and then in
19 2010 I won the -- I was awarded the Key Award, which
20 recognizes a member for their leadership role in various
21 activities and the association.

22 Q. Dr. Hatch, have you published any technical
23 papers, filed any patent applications, or given any talks
24 regarding water filtration?

25 A. Yes, I've published numerous papers -- they are

1 actually in my curriculum vitae -- technical papers on water
2 treatment, water disinfection, published in peer-reviewed
3 journals, technical journals, and also in trade journals,
4 given many talks at Water Quality Association conferences
5 and meetings.

6 Q. Thank you. Can we please turn to RDX-8.4.

7 Dr. Hatch, do you understand that Judge McNamara
8 has adopted the level of ordinary skill in the art that we
9 see here on RDX-8.4?

10 A. Yes, I do.

11 Q. Dr. Hatch, from about 2006 to 2009 did you
12 yourself satisfy this definition?

13 A. Yes, I believe I have, and have exceeded that
14 definition.

15 Q. And did you apply this definition when you formed
16 your opinions in this case?

17 A. Yes, I did.

18 Q. Okay. Dr. Hatch, do you consider yourself an
19 expert in the fields of water filtration, lead removal from
20 water, and the subject matter that the '141 patent is
21 directed?

22 A. Yes, I do.

23 MR. DAVISON: Your Honor, at this time
24 Respondents proffer Dr. Hatch as an expert in the fields of
25 water filtration, lead removal from water, and the subject

1 matter that the '141 patent is directed.

2 JUDGE MCNAMARA: Ms. Everett, do you have any --
3 does Brita have any objection?

4 MS. EVERETT: No objection, Your Honor.

5 JUDGE MCNAMARA: Then Dr. Hatch is so accepted as
6 an expert on the subject matters for which he has been
7 called to testify.

8 MR. DAVISON: Thank you, Your Honor.

9 Q. So, Dr. Hatch, we know you're an expert in water
10 filtration, but I want to talk about what you're not an
11 expert in.

12 Have you ever testified in a hearing before?

13 A. No, I haven't.

14 Q. And before this case have you ever submitted an
15 expert report in a patent case?

16 A. No, I haven't.

17 Q. And how about before this case, were you ever
18 deposed in a patent case?

19 A. No, I haven't.

20 MR. DAVISON: Your Honor, at this time I need to
21 briefly go on the confidential record, and this will be
22 Brita confidential information.

23 (Whereupon, the hearing proceeded in confidential
24 session.)

25

Appx23407-23409
redacted in their
entirety

1 O P E N S E S S I O N

2

3 JUDGE MCNAMARA: Okay. Very good. Go ahead,
4 please, Mr. Davison.

5 MR. DAVISON: Thank you, Your Honor.

6 BY MR. DAVISON:

7 Q. Mr. Campos, may we please go to RDX-8.5. Thank
8 you.

9 So, Dr. Hatch, what were you asked to do in
10 connection with this investigation?

11 A. Investigate certain issues with the '141 patent.

12 Q. Dr. Hatch, did you form an opinion as to whether
13 the asserted claims satisfy the written description
14 requirement?

15 A. Yes, I did.

16 Q. For written description, what is your ultimate
17 opinion?

18 A. There were two issues: That the inventors did
19 not possess or achieve the -- all of the claimed numerical
20 FRAP ranges, and, second, the inventors did not possess all
21 of the claimed types of filters.

22 Q. Dr. Hatch, did you form an opinion as to whether
23 the asserted claims satisfy the enablement requirement?

24 A. Yes, I did.

25 Q. And for enablement, what is your ultimate

1 opinion, Dr. Hatch?

2 A. That the '141 patent would -- did not enable a
3 person of skill in the art to make or achieve the full range
4 of FRAP numbers without undue experimentation.

5 Q. Dr. Hatch, do you recall that there were some
6 other opinions in your reports about topics such as
7 obviousness and anticipation?

8 A. Yes.

9 Q. And are you planning to talk about those other
10 opinions about obviousness and anticipation here today?

11 A. No. I think that's to be addressed by other
12 counsel.

13 Q. Thank you. Are you aware that Judge McNamara
14 construed certain terms of the '141 patent in Order No. 30?

15 A. Yes.

16 Q. And have you reviewed Order No. 30?

17 A. Yes, I did.

18 Q. And did you apply those constructions when you
19 formed your opinions on written description enablement?

20 A. Yes, I did.

21 Q. And if a term was not construed by Judge
22 McNamara, how did you interpret it?

23 A. By its plain and ordinary meaning.

24 Q. Dr. Hatch, do you understand that there's a
25 dispute as to the priority date of the '141 patent?

1 A. Yes.

2 Q. Do your opinions with respect to written
3 description or enablement change based on the priority date
4 of the '141 patent?

5 A. No, they do not.

6 Q. Okay. Dr. Hatch, I'd like to turn to your first
7 opinion regarding written description.

8 Can we please have RDX-8.9.

9 As an initial matter, can you explain to us what
10 numerical range, if any, is required for claims 1 and 2?

11 A. For claim 1 it's stated that a FRAP factor is
12 less than about 350 and claim 2 a FRAP factor of less than
13 about 200.

14 Q. Okay. Can we turn to RDX-8.10.

15 So, Dr. Hatch, in RDX-8.10 I see Table 5 from the
16 '141 patent.

17 What type of information is contained in Table 5?

18 A. On Table 5 is a table consisting of the summary
19 of the test results of some of the working examples, and
20 on -- such as the life, L, F, the flow factor, what I call
21 the flow factor in minutes per liter, and in column V for
22 the volume of the media, filter media, and column C for the
23 lead value, effluent value, in the -- at the end of the
24 life, and the far right column is a column showing the FRAP
25 numbers of each of these filters that were tested.

1 Q. Are there any working examples in the '141 patent
2 that aren't depicted in Table 5?

3 A. No, they're all here.

4 Q. Okay. Now I see two red boxes on RDX-8.10.

5 Can you explain what are those red boxes
6 indicate?

7 A. On the far right column, the red boxes show the
8 FRAP numbers for the working -- first nine working examples,
9 and below the large red box is a smaller red box showing the
10 cylindrical blocks, blocks 1 and 2, the FRAP numbers for
11 those two examples.

12 Q. Okay. Now there's not a red box around the FRAP
13 values for the P2-9 lead sorbent free and the P2-6 lead
14 sorbent free. Why?

15 A. Well, because, as described, they do not contain
16 a lead scavenger and, therefore, do not fall under claim 1.

17 Q. Okay. And I see five FRAP values for mixed-media
18 filters.

19 Why is there not a red box around those values?

20 A. Well, again, if you look at all the FRAP values
21 given there for those filters, they do not meet the 350 or
22 less FRAP requirement in claim 1. So they are left out.

23 Q. Okay. Do the red boxes on RDX-8.10 indicate the
24 FRAP values for the working examples that practice claims 1
25 or 2 of the '141 patent?

1 A. Yes.

2 Q. Okay. Can we turn to our next demonstrative,
3 RDX-8.11.

4 Can you explain RDX-8.11 to us, starting with the
5 table on the left-hand side of the demonstrative?

6 A. Sure. The table on the left-hand side is
7 excerpted data from Table 5, which just includes the
8 description of the samples and just the FRAP values.

9 I should mention that in the column of FRAP
10 factors, the far right column is the corrected FRAP factor
11 that's represented in the '141 patent. And on the right we
12 have graphically shown how they lay out here, the FRAP
13 numbers lay out, relative to the claimed requirement for
14 FRAP range of 350 or less, which is the green line at the
15 top, and the claim 2 of 200 or less, which is the yellow
16 line, and the scale at the bottom is the FRAP number from 0
17 to 350.

18 You'll see the nine filter examples, FRAP
19 numbers, are bunched to the far left, and then the
20 cylindrical block samples are the two datapoints on the far
21 right. And you'll see there's a widespread in between
22 with -- without any data whatsoever showing a range, a full
23 range of the FRAP values that were claimed in claim 1.

24 Q. Dr. Hatch, other than the FRAP values that we see
25 here on RDX-8.11, does the '141 patent disclose any other

1 FRAP value for any filter that would practice claims 1 or 2?

2 A. No, it does not.

3 Q. Does the specification provide any directions for
4 modifying the working examples to achieve the other FRAP
5 values claimed?

6 A. No, it does not.

7 Q. Can we turn to RDX-8.12.

8 Dr. Hatch, can you explain this demonstrative to
9 me?

10 A. Sure. If you look, first look at the lower
11 left-hand corner where was the original -- the previous
12 slide, and I've enlarged the left side of the graph and have
13 annotated the graph, cut off the graph to show -- still show
14 the full range of FRAP 350 or less and 200 or less. And
15 you'll see where I plotted the lowest FRAP range from those
16 nine filters at 6.7, but the claim, claims 1 and 2, go from
17 0 to 350.

18 So what I'm showing here in this graph is that
19 there are no examples showing any FRAP range between 0 and
20 6.7. There's missing a range of FRAP numbers shown in this
21 graph.

22 Q. So, Dr. Hatch, do claims 1 and 2 include FRAP
23 values below 6.7?

24 A. Yes, it does.

25 Q. And does the specification of the '141 patent

1 provide any directions for modifying the working examples to
2 achieve a FRAP below 6.7?

3 A. No, it does not.

4 Q. And would a person of skill in the art understand
5 that the inventors possessed a filter with a FRAP below 6.7?

6 A. No, they would not.

7 Q. Can we have our next demonstrative, RDX-8.13,
8 please.

9 Dr. Hatch, why would a person of skill in the art
10 understand that the inventors were not possessing a filter
11 with a FRAP value below 6.7?

12 A. There are no working examples in the '141 patent
13 that exhibited a FRAP value below 6.7. And as
14 Dr. Knipmeyer, here in her testimony, states that when you
15 look at the formula, the variables there are interrelated,
16 and, as a matter of fact, if you begin changing one of those
17 variables to achieve a different FRAP number, the other
18 variables will most likely change, and end up with an
19 unpredictable result.

20 Q. Thank you. So, Dr. Hatch, would a person of
21 skill in the art understand that the inventors were in
22 possession of the entire range of claim 1's FRAP factor of
23 about 350 or less?

24 A. No, they would not.

25 Q. And how about for claim 2, would a person of

1 skill in the art understand the inventors were in possession
2 of the entire range of claim 2's FRAP factor of about 200 or
3 less?

4 A. No, they would not.

5 Q. Let's turn to RDX-8.14.

6 We can discuss claims 3 and 4. As an initial
7 matter, can you remind us, what is required by claims 3 and
8 4?

9 A. Claim 3, claims 3 and 4, this is about the volume
10 of the filter media, and claim 3 cites that the filter media
11 volume is less than 300 cubic centimeters and claim 4, the
12 volume of the filter media is less than about 150 cubic
13 centimeters.

14 Q. Thank you. Let's turn to RDX-8.15, please.

15 Dr. Hatch, I see Table 5 again. Can you explain
16 the annotations that are on RDX-8.15 to us?

17 A. Yes. This is, again, Table 5, which we're now
18 looking at the red boxes that cover the volumes of the
19 example filters that were made and tested.

20 And there's only two volumes here representing
21 filters, 89 cubic centimeters and 151 cubic centimeters.

22 Q. Okay. Again, I see we don't have a red box
23 around the V values for the P2-8 lead sorbent-free and the
24 P2-6 lead sorbent-free. Why is that?

25 A. Again, they are defined as not having a lead

1 scavenger, therefore, they do not fall under the claim 1.

2 Q. Okay. And then there's five mixed-media filters.

3 Why is there not a red box around the volumes
4 associated with those five filters?

5 A. Well, again, they do not FRAP, their FRAP values
6 are all above 350 and they do not fall under claim 1.

7 Q. Let's turn to RDX-8.16.

8 So, Dr. Hatch, can you explain RDX-8.16 to us
9 starting with the table on the left-hand side of the
10 demonstrative, please?

11 A. Sure. There, again, we see excerpted the volume
12 column and put on the left next to each of the sample
13 filters that were made and tested. And you'll see when we
14 plot these two volumes on the graph, to the right, again,
15 showing the full volume claim now, the horizontal axis is
16 volume in cubic centimeters, we can see how the whole range
17 of the claimed volume is -- only has two datapoints, and
18 there's a lot of missing ranges there with regard to volume
19 of filter medium.

20 Q. Okay. Let's turn to RDX-8.17.

21 And it looks like RDX-8.17 adds something from
22 RDX-8.16.

23 Can you explain this to us?

24 A. Yeah. Just as I pointed out, now these red lines
25 actually depict the missing ranges of volumes that are

1 covered under the '141 patent, which is 300 cubic
2 centimeters and 150 cubic centimeters. And so from 0 to 89
3 cubic centimeters, 89 to 151, and from 151 to 300 cubic
4 centimeters there are no working examples shown or made and
5 they're missing from the '141 patent.

6 Q. So other than the two volumes that are shown on
7 RDX-8.17, does the '141 patent disclose any other volumes
8 for filters that practice claims 3 or 4?

9 A. No, it does not.

10 Q. Does the specification provide a person of skill
11 in the art any directions for modifying the working examples
12 to achieve the full scope of the claimed volumes?

13 A. No, it does not.

14 Q. And so, Dr. Hatch, would a person of skill in the
15 art understand the inventors were in possession of the
16 entire range of claim 3?

17 A. No, it would not.

18 Q. And, Dr. Hatch, would a person of skill in the
19 art understand the inventors were in possession of the
20 entire range of claim 4?

21 A. No, it would not.

22 Q. And, recall, when Judge McNamara asked us, she
23 wants to know the why, so why would a person of skill in the
24 art reach that conclusion?

25 A. Again, as stated, in looking at the figures that

1 I just posted, these figures show that only two sets of
2 examples, one with 89 cubic centimeters and one set with 151
3 cubic centimeters, are the only two representative sets of
4 examples of volume that are shown in the '141 patent.

5 Q. Mr. Campos, can we turn to RDX-8.18, please, and
6 claims 5 and 6.

7 Dr. Hatch, what is required by claims 5 and 6?

8 A. Well, here we have claims 5 and 6, which involve
9 the -- what I call the flow factor or filtration unit time,
10 and claim 5 is the average filtration unit time of less than
11 about 12 minutes per liter, and claim 6 is the average
12 filtration unit time less than about 6 minutes per liter.

13 Q. Can we turn to RDX-8.19, please.

14 Sorry. 8.20. No, 8.19. Thank you.

15 All right. So we're on RDX-8.19. Dr. Hatch, can
16 you explain the annotations that are made on Table 5 here?

17 A. Sure. This, again, Table 5, from the '141
18 patent, showing the f factor, the f variable, and the
19 units -- it's important to understand that the units of this
20 f factor are minutes per liter. So it's how many minutes
21 does it take to flow a liter through the filter.

22 And you'll see the nine samples range anywhere
23 from 4.2 to about 5.7 minutes per liter, and the cylindrical
24 block samples, only one is annotated there as 9.9 minutes
25 per liter.

1 Q. Okay. So it looks like there's no red box around
2 the f values for the P2-8 lead sorbent free, the P2-6 lead
3 sorbent free, and the five mixed-media filters.

4 Why is that?

5 A. Again, the P2-8 and the P2-6 are described as not
6 having lead sorbent, and, therefore, they don't fall under
7 claim 1, and block 1, as you see in the cylindrical block
8 data for the f factor, it shows a 17, which is above the 12
9 minutes per liter flow range. And so that did not meet the
10 requirement for claim 5.

11 Q. Thank you. Let's turn to our next demonstrative,
12 RDX-8.20.

13 All right. Dr. Hatch, can you explain RDX-8.20
14 to us? What are we looking at here?

15 A. Here, again, I've excerpted the f values for the
16 working examples presented in Table 5 showing, as I've
17 pointed out before, the nine filters range from 4.20 to 5.7
18 minutes per liter and the -- only block 2 was represented as
19 giving a 9.9 minutes per liter.

20 And in the far right graph, again, shows the
21 green line, which is the 12 minutes per liter, and here the
22 horizontal axis at the bottom is the f factor from 0 to 12,
23 and claim 6 is 6 minutes per liter.

24 And you'll see kind of almost in the left central
25 part of the graph the values for the first -- or the working

1 examples gave a flow factor of 4.2 to 5.7, and then the far
2 right datapoint is block number 2 at 9.9 minutes per liter.

3 Q. Thank you. Let's turn to RDX-8.21.

4 And it looks like RDX-8.21 adds a few things to
5 RDX-8.20.

6 Can you explain what has been added?

7 A. Yeah. Again, here we have an issue with the flow
8 range as the f factor gets lower and lower, and the -- there
9 are no working examples exhibiting a flow range of less than
10 4.2. And this herein gets complicated and difficult,
11 because, remember, that as you get lower and lower of an f
12 factor, the volumetric flow rate becomes higher and higher.

13 If you'll look at the bottom, the very bottom of
14 the graph on the right, you'll see a line there on the far
15 right that says slow, and as you proceed to the left it
16 turns green, and the word says fast. That's representing
17 the volumetric flow rate. So as you get -- as a matter of
18 fact, if you have an f factor of 6 and you want to achieve a
19 f factor of 3, you have to double the flow rate.

20 So and then as you proceed further and further to
21 the left, the flow rate begins to rapidly increase; however,
22 the flow rate ranges on the low end are what we are seeing
23 here now are unbounded. There is no lower boundary given in
24 the claims 5 and 6 for the f factor or the volumetric flow
25 rate.

1 Q. I want to go over this a little bit more to make
2 sure I really understand it. So let's say I have my PUR
3 pitcher right here.

4 Which end of the axis on RDX-8.21 means my PUR
5 pitcher is filtering water slowly?

6 A. It would be the far right of that graph with a
7 higher and higher f factor, because it takes -- for
8 instance, 12 minutes per liter means it takes you 12 minutes
9 just to get one liter, whereas, if you're on, say, 4, 4.2,
10 it would take only 4.2 minutes to get a liter of water
11 through a filter.

12 Q. So with my same example, I've got my pitcher
13 here, if I get closer towards 0, that means my pitcher is
14 filtering water faster?

15 A. Very fast, as you approach 0, the flow rate
16 becomes extremely high.

17 Q. You say "very fast." What's the limit for the
18 flow rate covered by claims 5 and 6?

19 A. The lower range as defined in the patent is,
20 basically, as low as you can go, .001 could be an f factor,
21 which translates to a thousand liters per minute, which,
22 according to my calculations, is about 264 gallons per
23 minute.

24 Q. Sticking with that, a thousand liters per minute,
25 does the '141 patent provide sufficient written description

1 to enable a person of skill in the art to make a water
2 pitcher that filters a thousand liters per minute?

3 A. There's no teaching in the '141 patent to show
4 how to do that, no.

5 Q. Okay. So looking at RDX-8.21, other than the
6 average filtration times that are shown on this
7 demonstrative, does the '141 patent disclose any other
8 average filtration time values for filters that practice
9 claims 5 or 6?

10 A. No, it does not.

11 Q. And does the '141 patent provide any directions
12 for modifying the working examples to achieve the full scope
13 of the claimed f value?

14 A. No, it does not.

15 Q. We talked about the limits on flow rate for
16 claims 5 and 6, but what about the flow rate input to claim
17 1? Is there any limit on the average filtration time value
18 for claim 1?

19 A. As claim 1 is written, there are no given ranges
20 for flow rate, no.

21 Q. Is the flow rate input to the FRAP equation for
22 claim 1 also unbounded?

23 A. Yes.

24 Q. So, Dr. Hatch, would a person of skill in the art
25 understand the inventors were in possession of the entire

1 range of claim 5?

2 A. No, they would not.

3 Q. How about claim 6, would a person of skill in the
4 art understand the inventors were in possession of the
5 entire range of claim 6?

6 A. No they would not.

7 Q. And, again, why? Why would a person of skill in
8 the art reach that conclusion about claims 5 and 6?

9 A. Well, as shown in the previous graphs, there were
10 wide missing ranges of examples exhibiting those missing
11 flow ranges, that they're not existent in the '141 patent.

12 Q. Thank you. Can we have RDX-8.22.

13 Dr. Hatch, I want to switch gears and talk about
14 your second written description theory. Is that okay?

15 A. Yes.

16 Q. All right. Let's turn to RDX-8.23, please.

17 What type of gravity filters are disclosed in the
18 working examples that implement the asserted claims of the
19 '141 patent?

20 A. The only working examples in the '141 patent are
21 carbon block filters.

22 Q. Are carbon block filters the only ones?

23 A. Yes.

24 Q. But is the invention of the '141 patent limited
25 to carbon block filters?

1 A. No.

2 Q. What other type of filters does the '141 patent
3 say it includes?

4 A. Well, according to the presentation in the '141
5 patent, it can virtually almost include everything, as
6 written in the language here that's shown, can include many
7 other things, and actually includes other embodiments of the
8 present invention, such as membranes, nonwovens, depth
9 media, nanoparticles, nanofibers and ligands.

10 Q. For the record, are you referencing the '141
11 patent which is JX-22 at lines 26, 30 to 37?

12 A. Yes, I am.

13 Q. What I want to do now is walk through those other
14 filter types. So let's turn to RDX-8.24.

15 Starting with carbon blocks, Dr. Hatch, does the
16 '141 patent provide detail or examples as to how to make
17 carbon block filters?

18 A. Yes, it does.

19 Q. RDX-8.25.

20 Does the '141 patent provide any detail or
21 examples as to how to make a mixed-media filter that would
22 achieve any of the asserted claims?

23 A. No, it does not, and actually it states it, as
24 seen here in the demonstrative, no mixed-media filters
25 tested met the claimed FRAP factor range due to their

1 inability to remove particulate lead.

2 Q. Okay. And, for the record, are you referencing
3 the '141 patent at lines or column 26, lines 60-65?

4 A. Yes, I am.

5 JUDGE MCNAMARA: Okay. Pardon me, Mr. Davison.

6 Q. Does the --

7 JUDGE MCNAMARA: Mr. Davison, this is a good
8 stopping point, so we're going to take five minutes at this
9 point and give everybody a break. So I'll see you back here
10 in five minutes.

11 (Whereupon, the proceedings recessed at 10:30
12 a.m.)

13 (In session at 10:35 a.m.)

14 JUDGE MCNAMARA: Thank you everybody. We're back
15 on the record.

16 Mr. Davison?

17 MR. DAVISON: May I proceed, Your Honor?

18 JUDGE MCNAMARA: Yes. Thank you.

19 BY MR. DAVISON:

20 Q. So let's go back to RDX-8.25, please.

21 I want to continue our discussion, Dr. Hatch,
22 regarding mixed-media filters. Okay?

23 So what does the '141 patent have to say about
24 mixed-media filters?

25 A. Actually, they don't perform with regard to

1 removing particulate lead.

2 Q. And does the '141 patent provide any directions
3 for modifying the working examples to implement the asserted
4 claims in a mixed-media filter?

5 A. No, it does not.

6 Q. And would a person of skill in the art reading
7 the '141 patent understand that the inventors were in
8 possession of a mixed-media filter that could achieve any of
9 the asserted claims?

10 A. No, they would not.

11 Q. Thank you. Let's turn to RDX-8.26.

12 Membrane filters, Dr. Hatch. Does the '141
13 patent provide any detail or examples as to how to make a
14 membrane filter that would achieve the functional
15 performance required by any of the asserted claims?

16 A. No, it does not.

17 Q. Are there any examples or directions for
18 modifying the working examples to implement the '141 patent
19 in a membrane filter?

20 A. No, there are not.

21 Q. And a person of skill in the art, when they're
22 reading the '141 patent, would they understand that the
23 inventors were in possession of a membrane filter that could
24 achieve the asserted claims?

25 A. No, they would not.

1 Q. All right. RDX-8.27, please.

2 We're now talking about nonwoven filters.

3 So does the '141 patent provide any detail or
4 examples as to how to make a nonwoven filter to achieve the
5 functional performance required by the asserted claims?

6 A. No, it does not.

7 Q. And are there any directions in the '141 patent
8 to modify the working examples to implement the asserted
9 claims in a nonwoven filter?

10 A. No, there are not.

11 Q. Okay. RDX-8.28, please.

12 And I'm going to group the next four filter types
13 together. Let's talk about depth media, nanoparticles,
14 nanofibers, and ligand filters together. Is that okay?

15 A. Sure.

16 Q. All right. Does the '141 patent provide any
17 detail or examples as to how to make a depth media filter, a
18 nanoparticle filter, a nanofiber filter, or a ligands filter
19 to achieve the functional performance required by the
20 asserted claims?

21 A. No, it does not.

22 Q. Are there any directions for modifying the
23 working examples to implement the asserted claims in a depth
24 media filter, a nanoparticle filter, a nanofiber filter, or
25 a ligands filter?

1 A. No, there are not.

2 Q. And a person of skill in the art, when he is
3 sitting down and reads the one patent, he or she, does that
4 person of skill in the art understand that the inventors
5 were in possession of a depth media filter, a nanoparticle
6 filter, a nanofiber filter, or a ligands filter?

7 A. No, they would not.

8 Q. Dr. Hatch, why does a person of skill in the art
9 reach that conclusion, why, when they are reading the '141
10 patent, do they think the inventors were not in possession
11 of all these filter types?

12 A. Nothing is mentioned about making any working
13 samples or examples employing those specific filter
14 techniques. They're not mentioned at all, how to do that,
15 in the '141 patent.

16 Q. And the excerpt that we're looking at on this
17 demonstrative, it's JX-22, column 26, lines 30-37, is there
18 anything else in the '141 patent that discusses membrane
19 filters, nonwoven filters, depth media filters, nanoparticle
20 filters, nanofiber filters, or ligands filters?

21 A. No, nothing.

22 Q. Thank you. Could we have RDX-8.29?

23 I want to completely switch topics, Dr. Hatch.
24 Can we turn to your enable theories now?

25 A. Sure.

1 Q. Let's turn to RDX-8.30.

2 So, Dr. Hatch, can you explain your enablement
3 opinion to us as it relates to the ranges claimed in claims
4 1 and 2?

5 A. Yes. Here we show the truncated figure regarding
6 FRAP factor and claim 1 being 350 or less, claim 2, 200 or
7 less, and the lowest value FRAP factor of the example,
8 carbon block example, that was excerpted from Table 5.

9 And, here, again, I demonstrate the FRAP factor,
10 any FRAP factor below 6.7 is not shown in the '141 patent,
11 and here, again, I claim that it's my opinion that it would
12 require undue experimentation based on the unpredictability
13 of the FRAP equation to achieve the very low end of a FRAP
14 number for a pitcher filter as claimed in '141.

15 Q. Thank you. Let's turn to RDX-8.31.

16 Can you explain your enablement opinion to us as
17 it relates to claims 3 and 4?

18 A. Yes. The same situation here. The missing
19 ranges with the only two datapoints we see for two sets of
20 filters having only two sets of volumes, 89 and 151, and you
21 see the wide range of missing data for these different
22 volumes of filters are just not represented in the '141
23 patent.

24 Q. Thank you. So let's turn to RDX-8.32.

25 Can you explain your enablement opinion to us as

1 it relates to claims 5 and 6?

2 A. Here, again, is the graph on the right showing
3 the flow ranges of the working examples, and, again, the low
4 end showing the f factor of less than 4.2, as I explained
5 before, the FRAP equation, once you start getting at that
6 very, very low flow factor, which means a very, very high
7 flow rate, in my opinion it would take undue experimentation
8 to achieve a filter that would meet the very low end of this
9 flow range with a very high flow rate.

10 Q. Thanks. I want to focus on something you said,
11 the "undue experimentation." Let's talk about that.

12 Let's go to RDX-8.33.

13 Dr. Hatch, with respect to the asserted claims in
14 your enablement opinions, did you consider whether the
15 specification enables a person of skill in the art to make
16 the invention without undue experimentation?

17 A. Yes, I did.

18 Q. And, again, what was your determination?

19 A. Here I list the main issues involved is, again,
20 the absence of working examples showing how filters could
21 meet those missing ranges. The working examples are not
22 there.

23 And there are no -- as we pointed out, there's no
24 direction or guidance to either modify the existing carbon
25 block filters to make filters to achieve those missing

1 ranges.

2 And, of course, the breadth of claims that are
3 claimed in claims 1 through 6 with regard to volume, flow,
4 and the lead value and the life are such wide claims and are
5 not represented by any filter in the '141 patent.

6 So one skilled in the art, just relying on prior
7 art, would not be able to enable the person of skill in the
8 art to make these working examples from these other filter
9 techniques without undue experimentation.

10 Q. Thank you. Let's turn to RDX-8.34. I want to go
11 over these factors a little bit more.

12 The red boxes that we see here on RDX-8.34, those
13 are the working examples -- are those the working examples
14 that we've been looking at today?

15 A. Yes, they are.

16 Q. Okay. So other than the working examples that we
17 see in the red box on RDX-34, are there any other working
18 examples in the '141 patent for the asserted claims?

19 A. No.

20 Q. And is there any direction or guidance anywhere
21 in the '141 patent to modify any of these working examples
22 to implement the claimed ranges?

23 A. No, there's not.

24 Q. And the breadth of the claims, how did you
25 consider this factor?

1 A. By looking at what is presented by the working
2 examples and showing what the missing ranges are for each of
3 these working examples for the f factor, the volume, and
4 FRAP factors, and comparing the data that is presented shows
5 such broad missing ranges that they just don't cover the
6 full breadth of the claimed ranges.

7 Q. So let's turn to RDX-8.35.

8 And I see the FRAP equation on RDX-8.35.

9 Is the calculation of a FRAP value a routine
10 measurement in the water filtration industry?

11 A. No, it is not.

12 Q. In your 49 years of work in the water filtration
13 industry, prior to this case, have you ever heard of anybody
14 calculating a FRAP?

15 A. No, I've not.

16 Q. Let's look at the inputs to the FRAP equation,
17 though.

18 Dr. Hatch, would a person of skill in the art
19 know how to calculate the volume of a filter, the V value?

20 A. The individual volume of the filter media
21 should -- a person of skill in the art should know how to do
22 that, yes.

23 Q. Okay. Let's go to our next variable, f, so
24 average filtration time.

25 Does a person of skill in the art know how to

1 determine the f value?

2 A. That involves the volumetric flow rate of the
3 water passing through the filter in a certain unit of time,
4 yes, that should be easy for a person of skill in the art to
5 measure that, yes.

6 Q. Okay. Sticking with our numerator, let's go to
7 the next value, the Ce.

8 Does a person of skill in the art know how to
9 determine the Ce value for a filter?

10 A. Yes, for a lead test, samples can be taken and
11 submitted to a lab, and the lab reports analyze the sample
12 for lead and reports that back to a person of skill in the
13 art. That's a routine procedure to determine lead content
14 in a water sample.

15 Q. Let's go to our denominator and look at L. Can a
16 person of skill in the art determine the L value?

17 A. Yes, if it's, again, if it's properly defined as
18 to what the L gallons life of the filter -- how it's to be
19 determined. It should be fairly easy for one skilled in the
20 art to determine what the life of the filter would be.

21 Q. Okay. Dr. Hatch, how is it, then, that if the
22 inputs of the FRAP equation can be determined by a person of
23 skill in the art that you say it takes undue experimentation
24 to implement the claimed ranges?

25 A. That is an issue here with regard to how these

1 individual values affect each other. Let's take one of the
2 more obvious variables here to change and see what happens
3 to the other variables and what ends up happening to the
4 FRAP value.

5 Let's say we take the volume and let's say --
6 let's say we want to make a low -- try to get a low FRAP
7 value. So one way to do that is to lower the factors in the
8 denominator -- I'm sorry -- the numerator, the top
9 variables.

10 So we lower those. Let's lower volume. If we
11 lower the volume, what happens? The volume is lower -- less
12 volume, as water passes through a media, if there's less
13 volume there, most likely your flow rate is -- you're going
14 to have less resistance to flow. So the flow rate will go
15 up.

16 Now, remember, the f factor is minutes per liter.
17 If the flow rate goes up, f will get smaller, so f goes
18 down. So now you're on a track of lowering your FRAP
19 number.

20 However, you have less volume, you have less
21 media volume, which means you don't have the capacity of
22 that media to remove lead as you had before. Also, when
23 your flow rate gets faster, you have less contact time and
24 filtration and absorption, your dynamics are such that you
25 have less time to absorb lead. So you got two factors

1 there, though you're lowering V and f, your lead value most
2 likely will go up.

3 Now that means you're going the opposite
4 direction if you want to lower your FRAP number. Not only
5 that, if your lead value goes up, you most likely --
6 remember, you're lowering the volume too -- so your life, if
7 you have less volume, obviously your life is going to be
8 lower. Your lead value, coming out of the filter, the
9 effluent value at the end of life, life is going to get
10 smaller, and L is in the denominator. When your denominator
11 gets smaller, your FRAP value is going to go up.

12 So when you change one of these factors, you do
13 not know what is going to be the final result of your FRAP
14 value, and this is -- this is a conundrum with the FRAP
15 equation, which creates unpredictability in knowing what
16 changing one variable is going to do to the others and end
17 up in a result -- whatever result of a FRAP value you think
18 you might get.

19 Q. Okay. A few follow-up questions on your
20 explanation.

21 So are the inputs to the FRAP equation, the V,
22 the f, the Ce, and L, are they interrelated?

23 A. As I explained, they have -- they do -- they are
24 interrelated, and you change one, that has an effect on the
25 others.

1 Q. Does the '141 patent explain when you change one,
2 what that impact will be on the others?

3 A. No, it does not.

4 Q. Is the state of the art of gravity-fed filters,
5 is it unpredictable?

6 A. The state of the art of gravity-fed --

7 Q. With the FRAP equation, is that unpredictable?

8 A. It would be if you base it on this FRAP equation.

9 Q. Thank you. Let's turn to RDX-8.36.

10 Dr. Hatch, I want to turn to your final opinion
11 on enablement, if that's all right.

12 A. Yes.

13 Q. So let's go to RDX-8.37.

14 Dr. Hatch, did you consider whether the
15 specification of the '141 patent enables a person of skill
16 in the art to implement the asserted claims in the various
17 filter types that we see here on RDX-8.37?

18 A. Yes, I did.

19 Q. And what was your determination?

20 A. Well, first, what's depicted and explained and
21 tested, made and tested in the '141 patent, as it exists, is
22 there are only carbon block filters made and tested. It's
23 the only nature of the invention that's shown.

24 However, there are, they claim these other
25 filtration techniques, and there's no working examples of

1 any of these other filtration techniques that are mentioned
2 in the presentation. And no guidance or direction to
3 showing in the '141 patent to direct a person of skill in
4 the art to be able to either incorporate these filtration
5 techniques into a carbon block or in and of themselves make
6 a gravity-fed filter to employ those techniques to meet --
7 especially meet the broad breadth of claims that are shown
8 in the '141 patent.

9 So a person of skill in the art having perhaps
10 only the prior art to guide him and nothing more, nothing in
11 the '141 patent to guide him, would not be able to make or
12 use these other filter techniques without undue
13 experimentation.

14 Q. Okay. Dr. Hatch, weren't mixed-media filters,
15 membrane filters, nonwoven filters, depth media filters,
16 nanoparticle filters, nanofiber filters, and ligands filters
17 known in the prior art?

18 A. Oh, yes, they were.

19 Q. Okay. And a person of skill in the art, wouldn't
20 they know about mixed-media filters, membrane, nonwoven,
21 depth media, nanoparticle, nanofiber and ligands filters?

22 A. They would know about them, yes.

23 Q. Dr. Hatch, if the filters are known in the art
24 and persons of skill in the art knew about them, then why is
25 it that it takes undue experimentation to implement the

1 asserted claims of the '141 patent into these known filter
2 types?

3 A. Well, first of all, you have to understand the
4 detail of experimentation and you have to go through --
5 which in my 49 years of experience -- I've done it many
6 times, and it takes a lot of experimentation to take what's
7 required to remove particulate lead and soluble lead and
8 incorporate that technology into a gravity-fed filter.

9 Currently there are probably four or five
10 different -- at least four or five different lead absorbents
11 on the market, and you would have to take each one of those
12 and study each one. They're all probably -- I know they're
13 all different particle sizes, and how do you incorporate
14 them into a nonwoven to allow enough of it to be there to
15 absorb soluble lead and also make the nonwoven material fine
16 enough to filter the extremely fine .1 micron particles of
17 lead. I've done it, and it takes -- believe me, it takes an
18 undue amount of experimentation to be able to design and be
19 able to develop a filter to achieve -- especially achieve
20 all the broad range of claims that are depicted in the '141
21 patent.

22 Q. Thank you.

23 MS. EVERETT: Objection, Your Honor. That last
24 answer went beyond the scope of his expert report.

25 MR. DAVISON: Your Honor, I believe there might

1 be an objection, but I can't hear.

2 JUDGE MCNAMARA: Ms. Everett, I think Mr. Davison
3 is having problems again with his sound system. Could you
4 kindly repeat your objection?

5 MS. EVERETT: Sure. That last answer exceeded
6 the scope of his --

7 MR. DAVISON: Unfortunately, I'm not able to hear
8 anybody else speaking. I apologize.

9 JUDGE MCNAMARA: Okay. Let us know -- your mic
10 is off. It looks like your mic is off, Mr. Davison. Turn
11 your mic on.

12 Mr. Davison, your mic is off.

13 MR. SWAIN: Your Honor, this is Mr. Swain. I
14 know I can't be seen on camera right now. We are trying to
15 fix the problems in the room so that Mr. Davison can speak.
16 If you would just give us one moment. I apologize for the
17 technical difficulties.

18 JUDGE MCNAMARA: Sure. Ms. Everett, we'll have
19 to wait a moment.

20 MR. DAVISON: This is Mr. Davison speaking. I
21 can hear everyone now.

22 JUDGE MCNAMARA: Okay. Very good.

23 Ms. Everett, would you please repeat your
24 objection?

25 MS. EVERETT: Sure. That last answer went beyond

1 the scope of Dr. Hatch's expert report and his deposition
2 testimony.

3 JUDGE MCNAMARA: Can you be --

4 MS. EVERETT: I object as to outside the scope.

5 JUDGE MCNAMARA: Can you be explicit on page
6 numbers for both the expert report as well as for the
7 deposition testimony?

8 MS. EVERETT: I think that's actually up to
9 Mr. Davison to show us where that was in the expert report
10 and deposition testimony. Our position is it's outside the
11 scope.

12 JUDGE MCNAMARA: Well, actually it's up to you,
13 or I'm going to overrule the objection.

14 MS. EVERETT: Your Honor, Dr. Hatch just
15 testified to discussing how to make all these different
16 types of technology, and he did not disclose that in the
17 enablement section of his report. His enablement section is
18 three pages.

19 JUDGE MCNAMARA: So why don't you put it up on
20 the screen and show us.

21 MS. EVERETT: If we could pull up -- I don't know
22 if Mr. Rennick is allowed to control the screen.

23 JUDGE MCNAMARA: Sure.

24 MS. EVERETT: Dr. Hatch's lack of enablement
25 section begins on page 123 of his opening report, and it

1 continues to page 126. His answer just discussed analyzing
2 commercially available filtration media, size and particles,
3 and a number of experimentation. He discussed his
4 background and his 49 years. That is not contained on these
5 three pages.

6 JUDGE MCNAMARA: Okay. So here's -- it's okay,
7 you will have a chance to cross-examine Dr. Hatch.

8 So what I suggest, Ms. Everett, is that you go
9 into some detail on cross-examination. Your objection is
10 preserved, but I think it's up to you to go into
11 cross-examination on this.

12 MS. EVERETT: Thank you, Your Honor.

13 MR. DAVISON: Your Honor, Tom Davison speaking.
14 May I proceed?

15 JUDGE MCNAMARA: Yes. Ms. Everett, you also have
16 the option of -- look at my ground rules. You have the
17 option of filing a motion to strike, which effectively, I
18 think, your verbal statement just was without mentioning
19 that it's a motion to strike. But, again, you have a couple
20 of opportunities here. You can cross-examine, you can file
21 a motion to strike, you've preserved your objection, but you
22 can simply show us why it's beyond the scope when you get to
23 cross.

24 MS. EVERETT: Thank you, Your Honor.

25 MR. DAVISON: Tom Davison speaking. May I

1 proceed, Your Honor?

2 JUDGE MCNAMARA: Yes.

3 MR. DAVISON: Thank you. And, again, I apologize
4 for the slight technical difficulty we had.

5 BY MR. DAVISON:

6 Q. So, Dr. Hatch, picking up right where we left
7 off.

8 Can we put RDX-8.38 back up on the screen,
9 please.

10 So, again, Dr. Hatch, if all the filter types
11 that we're seeing on RDX-8.38, if mixed media, membrane,
12 nonwoven, depth media, nanoparticle, nanofiber, and ligands
13 filters, if they're known in the art and persons of skill in
14 the art knew about them, why is it, then, that a person of
15 skill in the art reading the '141 patent reaches the
16 conclusion that the inventors did not possess these filter
17 types to implement the asserted claims?

18 A. Again, because it's actually stated in the
19 presentation here in column 26, lines 60-65, that there are
20 no mixed -- as far as mixed-media, carbon and ion exchange
21 resins, there are no mixed-media filters tested that met the
22 claimed FRAP factor range due to their inability to remove
23 particulate lead, and in the '141 patent they tested
24 mixed-media filters, and none of them performed according to
25 the claims, and, again, the rest of those membranes,

1 nonwoven, depth media, nanoparticles, nanofibers and
2 ligands, there are no working examples presented in the '141
3 patent.

4 Q. Thank you, Dr. Hatch.

5 MR. DAVISON: I have no further questions.

6 JUDGE MCNAMARA: Thank you.

7 Ms. Everett, do you need a break before you get
8 started?

9 MS. EVERETT: Your Honor, I actually think if we
10 could just take a short break, that would be appreciated.
11 Thank you.

12 JUDGE MCNAMARA: Sure. How about if I see you
13 back here at 11:20?

14 MS. EVERETT: Okay. Thank you very much.

15 (Whereupon, the proceedings recessed at 11:04
16 a.m.)

17 (In session at 11:20 a.m.)

18 JUDGE MCNAMARA: All right. Thank you everyone.
19 Are you all set, Dr. Hatch?

20 THE WITNESS: I am all set, Judge McNamara.

21 JUDGE MCNAMARA: Thank you. All right.

22 Ms. Everett, you have the floor.

23 CROSS-EXAMINATION

24 BY MS. EVERETT:

25 Q. Welcome back, Dr. Hatch. It's good to see you.

1 I'm Uma Everett on behalf of Brita. We met this summer.

2 I'm glad you're feeling better.

3 A. Yes. Thank you. Good to see you too. Thank
4 you. I appreciate the good wishes.

5 Q. During your direct testimony, you testified
6 extensively to the working examples listed in the '141
7 patent, correct?

8 A. Yes.

9 Q. And you understand that for written description
10 you must consider the entire specification and the original
11 filed claims, correct?

12 A. Yes.

13 Q. And the original filed claims make up the written
14 description, support for the ultimately issued claims,
15 right?

16 A. Yes.

17 Q. So why don't we go ahead and look at the
18 originally filed claims.

19 Mr. Rennick, if you could bring up the file
20 history, JX-23, let's start at page 1.

21 Dr. Hatch, do you recognize this as the file
22 history, the application that became the '141 patent?

23 A. It looks familiar, yes.

24 Q. Okay. And so it is application '284, do you see
25 that?

1 A. Yes.

2 Q. And that was filed on September 9th, 2008?

3 A. Yes.

4 Q. Okay. And you see it is the patent at issue
5 here, it's the application for the patent here, '141?

6 A. Yes.

7 Q. Okay. And are you aware -- we can take this page
8 down for just a minute -- and are you aware that the '141
9 claims priority to the '372 application?

10 A. Could you repeat that? I didn't understand what
11 you were referring to.

12 Q. Sure. The '141 patent claims priority to the
13 '372 application. You're aware of that, right?

14 A. Okay. Yes.

15 Q. Okay. And I know you were not here -- I just
16 want to get a timeline going of what was filed when. I know
17 you were not here for the opening.

18 Were you able to look at the trial testimony and
19 slides that occurred in August?

20 A. I was not. I did not look at that or participate
21 in that due to my engagement with COVID.

22 Q. Okay. So you did not look at any trial testimony
23 afterwards, after the August time period?

24 A. I did look at, I think, Dr. Rockstraw's testimony
25 and Dr. Knipmeyer's testimony.

1 Q. Okay. Did you look at Respondents' opening
2 demonstratives?

3 A. I'm sorry, no, I did not.

4 Q. Okay. Okay. So let's, then, go back to the --
5 let's go back and compare the originally filed claims with
6 the issued claims.

7 Did you consider that as part of your opinion for
8 written description?

9 A. I don't recall that I was able to relate that to
10 the -- relate those, as you say.

11 Q. Okay. So is it fair to say you did not consider
12 the originally filed claims when forming your opinion on
13 written description?

14 A. I can't recall that I did. I don't know.

15 Q. Okay. So why don't we compare the originally
16 filed claims with the issued claims.

17 So, Mr. Rennick, if we could bring those two up
18 side by side. And, again, the patent is JX-22, the claims
19 are on pages 47-48. If we could bring that up on one side.
20 And on the other side, if we could bring up the file
21 history, JX-23, pages 112-113.

22 So let's start with claim 1. Can you see that?

23 A. If they're blown up a little bit more I could see
24 them better.

25 Q. So let's start with claim 1.

1 So can you see that actually at the top of the
2 screen is the issued claims from the patent and at the
3 bottom of the screen is the originally filed application?
4 Are you able to see that?

5 A. Yes.

6 Q. Okay. Let's just go line by line.

7 So for claim 1, what is claimed, 1, a gravity-fed
8 water filter, comprising.

9 Do you see that?

10 A. Yes.

11 Q. Same on both, right?

12 A. Yes.

13 Q. The next line, filter media including at least
14 activated carbon and a lead scavenger.

15 Do you see that?

16 A. Yes.

17 Q. And then the next line, wherein the filter
18 achieves a Filter Rate and Performance (FRAP) factor of
19 about 350 or less according to the following formula, and
20 then there is the FRAP formula.

21 Do you see that?

22 A. Yes.

23 Q. Okay. And then let's move on to the where clause
24 next.

25 So where, and then it sets forth the volume

1 equals the filter media centimeters cubed, yes?

2 A. Yes.

3 Q. And that is the same on the originally filed
4 application and the issued claim?

5 A. Uh-huh, yes.

6 Q. Let's go to f, flow rate, that's average
7 filtration unit time over lifetime L (minutes per liter).

8 Do you see that?

9 A. Yes, I do.

10 Q. It's the same, right?

11 A. Uh-huh, yes.

12 Q. Next, Ce, that is effluent lead concentration,
13 that is defined as the same in the originally filed
14 application as it is in the issued claim, correct?

15 A. It appears to be, yes.

16 Q. And then, finally, L, filter usage lifetime
17 claimed by the manufacturer or seller of the filter
18 (gallons).

19 Do you see that?

20 A. Yes.

21 Q. So claim 1, as filed, is exactly the same as
22 claim 1 issued, right?

23 A. Yes.

24 Q. And the originally filed claims provide written
25 description support for issued claims, yes?

1 A. Is that a question?

2 Q. Yes.

3 A. Oh. Do you want to repeat that, please?

4 Q. Sure. You understand that the written

5 description inquiry looks to the originally filed claims to

6 determine the written description support.

7 A. Again, I'm not a patent attorney, but it appears

8 to be that way, yes.

9 Q. Great. Now let's look at claim 2.

10 So claim 2 is also the same in the originally

11 filed application as it is in the issued claim, correct?

12 A. Yes.

13 Q. Okay. Thank you. Let's go to claim 3.

14 Claim 3, the issued claim is the same as the

15 originally filed application, correct?

16 A. Yes, it is.

17 Q. Okay. Claim 4. Claim 4 is -- the issued claim

18 is the same as the originally filed application, correct?

19 A. Yes, it is, the wording is the same.

20 Q. Okay. Claim 5? And claim 5, the issued claim is

21 the same as the originally filed claim, correct?

22 A. Yes, it is.

23 Q. Claim 6?

24 A. It appears to be the same, yes.

25 Q. Thank you. And then the final one, claim 23, I

1 think we have to flip the pages for both of those.

2 So let's go step by step. So on the left-hand
3 side we have the patent, and starting with the first part of
4 the claim -- it's a little long, so I want to make sure we
5 can get them on the screen -- do you see the first part of
6 the claim starting with the gravity-flow system -- excuse
7 me. Strike that.

8 Do you see the first part of the claim that says
9 a gravity-flow system for filtering water, comprising, a
10 container having a source water reservoir than can hold
11 source water and a filtered water reservoir that can hold
12 filtered water?

13 Do you see that?

14 A. Yes, I do.

15 Q. And that first part of claim 23 is identical in
16 both the issued claim and the originally filed claim.

17 A. Yes, it appears to be, yes.

18 Q. Okay. Thank you. And now we're going to go to
19 the second half of claim 23.

20 And the second half of claim 23 says, a cartridge
21 in communication with both the source water reservoir, and
22 it continues to say, as recited in claim 1 disposed within
23 the cartridge.

24 Do you see that?

25 A. Yes.

1 Q. I apologize, Dr. Hatch. I didn't mean to speak
2 over you.

3 A. Yeah, I see that. It appears to be the same.

4 Q. Okay. So you'll agree with me that the issued
5 claim 23 is the same as the originally filed claim 23.

6 A. Yes.

7 Q. Thank you. Now we can take these down.

8 And let's talk about claim 1. Claim 1 doesn't
9 require -- strike that.

10 Claim 1 only requires a gravity-fed water filter,
11 right? Among other -- strike that.

12 Actually, let's put claim 1 up, if you wouldn't
13 mind, Mr. Rennick, JX-22, page 47.

14 I'd like to focus on the first part of the claim.
15 The first part, it requires a gravity-fed water filter,
16 correct?

17 A. Yes.

18 Q. Claim 1 doesn't require a carbon block, right?

19 A. It doesn't mention a carbon block, no.

20 Q. Right. And the claim doesn't mention
21 mixed-media, right?

22 A. No.

23 Q. The claim doesn't mention nonwovens. Right?

24 A. No.

25 Q. The claim doesn't mention membranes.

1 A. No.

2 Q. The claim doesn't mention depth media.

3 A. No.

4 Q. The claim doesn't mention nanoparticles.

5 A. No.

6 Q. The claim doesn't mention nanofibers.

7 A. No.

8 Q. The claim doesn't mention ligands.

9 A. No.

10 Q. It just says gravity-fed water filter comprising
11 filter media including at least activated carbon and a lead
12 scavenger, right?

13 A. Yes.

14 Q. Okay. Now I'd like to look at some other parts
15 of the specification that you didn't discuss on your direct
16 testimony.

17 So the specification -- the inventors in the
18 specification confirmed that their invention applies to
19 types of filters besides carbon block, right?

20 A. Yes.

21 Q. So why don't we go to JX-22, page 43. I'm going
22 to -- Mr. Rennick, if we could go to column 25, lines 9-12.

23 And the specification states that the nature of
24 the filter meeting the following performance criteria is
25 independent of the exact embodiment of the filter, and thus

1 applicable to mixed-media, carbon blocks, nonwovens, hollow
2 fibers, and other filtration formats.

3 Do you see that?

4 A. Yes, I see it.

5 Q. Yes. And you did not focus on this part in your
6 testimony, right?

7 A. Not this part.

8 Q. Right. And you understand that an embodiment is
9 a type of one example of an invention, right?

10 A. That's what I understand to be.

11 Q. Now let's look at another part of the
12 specification you didn't focus on. Why don't we go to page
13 37, column 13, please. If you could go to 13, lines 31-34,
14 please.

15 And here the inventors have said several
16 potential filter materials are described below, while the
17 discussion will tend to focus on block filters, it should be
18 understood that the various materials may be used in
19 granular or loose media type filters, according to the
20 various embodiments of the present invention.

21 Do you see that?

22 A. Yes, I do.

23 Q. And so the specification states another example
24 for the invention would have filter media besides block
25 filters, right?

1 A. It discusses that.

2 Q. And it could be granular or loose media types
3 according to the various embodiments, right?

4 A. That's what it intends to say, yes.

5 Q. Let's go to yet another section you didn't talk
6 about in your direct.

7 Could we please go to page 34 and look at column
8 7, 20 and 21.

9 And do you see that, in other embodiments, the
10 filter media comprises primarily particles that are not
11 bound together? Is that what the specification says?

12 A. I see it, yes.

13 Q. Is that another way of saying that the filter
14 media could be loose or granular?

15 A. It could be --

16 Q. It could be --

17 A. -- a description, yes, a description of --

18 Q. I apologize, Dr. Hatch. Please continue.

19 A. Yeah, I was saying it could be a description of
20 loose particles.

21 Q. It could be -- could it be a description of more
22 than loose particles?

23 A. I don't know what -- what other particles you'd
24 be talking about.

25 Q. Anything that's not bound, right?

1 A. Could you elaborate more on that comment? I
2 don't quite understand where you're going here.

3 Q. Sure. I just want to make sure that this, when
4 it says here in other embodiments, the filter media
5 comprises primarily particles that are not bound together,
6 the inventors are discussing examples of their invention
7 that go beyond carbon blocks, right?

8 A. They appear to be, yes.

9 Q. Now I'd like to look at page 48, claim 20.
10 And claim 20 says the water filter recited in
11 claim 1, wherein the filter media comprises primarily
12 particles that are not bound together.

13 Do you see that?

14 A. I see it, yes.

15 Q. So you understand this is one of the claims in
16 the asserted patent?

17 A. Yes.

18 Q. Okay. And the inventors claimed a filter media
19 that was not bound, right?

20 A. Yes, that's what it says.

21 Q. So and when we say it's not bound, it goes beyond
22 a carbon block, right?

23 A. It could be, yes.

24 Q. Thank you. We can take these down.

25 Now, Dr. Hatch, I'd like to talk a little more

1 about the subject matter of these claims. A water filter,
2 it's a physical device, right?

3 A. Yes.

4 Q. You can touch it?

5 A. Yes.

6 Q. It has certain performance characteristics?

7 A. Most do, yes.

8 Q. Okay. These claims refer to filter media?

9 A. Yes. Yes, they do.

10 Q. And filter media is a physical item?

11 A. Yes.

12 Q. The claim references activated carbon?

13 A. One of the claims, yes.

14 Q. Strike that.

15 One of the limitations -- one of the limitations
16 of the claim refers to activated carbon, right?

17 A. Yes.

18 Q. Okay. And activated carbon is a physical
19 material?

20 A. Yes, it is.

21 Q. Claim 1 references a lead scavenger.

22 A. Yes, it does.

23 Q. And lead scavenger is a physical material.

24 A. Yes, it does.

25 Q. So the volume of the filter media can be

1 measured, right?

2 A. Usually, yes. There's a way to usually measure
3 most physical things.

4 Q. And that volume of the filter media affects the
5 performance of the filter, right?

6 A. Yes, it does.

7 Q. So now let's talk about flow rate. Flow rate,
8 that's a physical event, right?

9 A. Yes, it usually is.

10 Q. Flow rate can be measured?

11 A. Yes, it usually can, yes.

12 Q. Flow rate has certain performance
13 characteristics?

14 A. Could you repeat that, please?

15 Q. The flow rate allows for certain performance
16 characteristics of the filter?

17 A. Flow rate can determine the certain performance
18 characteristics of a filter.

19 Q. Okay. And lifetime is determined based on
20 certain performance criteria as well?

21 A. Usually, yes.

22 Q. So if a gravity-fed water filter is performing
23 effectively, it's going to have some filter media, right?

24 A. It depends on what you claim the filter to do.

25 Q. So let's look at claim 1. I want to be more

1 specific. I apologize. Claim 1.

2 So the filter in claim 1, if it is performing
3 effectively, it must have some filter media, right?

4 A. Based on the performance, yes.

5 Q. Okay. So if it's filtering water, the filter
6 media couldn't be 0, right?

7 A. Could you rephrase that or ask that again,
8 please?

9 Q. Sure. If the -- if the claim 1, the water filter
10 in claim 1, is effectively filtering water, the volume of
11 the filter media can't be 0, right?

12 A. So if there's -- you're saying if there is no
13 filter media, there's no performance, right? I think
14 that --

15 Q. I'm saying for claim 1, if there is a gravity-fed
16 water filter that meets claim 1 and it's effectively
17 filtering water, it must have some filter media, right?

18 A. If there is a performance, some performance of
19 the filter, there must be some media there to effect
20 performance.

21 Q. Got it. So if there's some media there, it must
22 be greater than 0, right?

23 A. Greater than 0.

24 Q. And if the claim 1, filter in claim 1, is
25 effectively filtering water, there will be some water

1 flowing out of the filter, right?

2 A. To produce water, treated water, it has to have
3 water emitting from it, yes.

4 Q. So the average filtration rate or flow rate has
5 to be greater than 0 as well, right?

6 A. It has to be some measurable amount.

7 Q. Which is greater than 0.

8 A. How much greater than 0 we don't know, but
9 greater than 0.

10 Q. Just to be clear, I just want to make sure, so if
11 the water filter in claim 1 is effectively filtering water,
12 the flow rate has to be greater than 0, right?

13 A. Yes.

14 Q. Okay. I want to turn to the state of the art,
15 the state of the art prior to this invention.

16 You agree that gravity-fed filters have been
17 known for a long time and used in homes to provide
18 better-tasting, safer drinking water, right?

19 A. Yes.

20 Q. And it's your position there were a number of
21 well-known filtration media materials used in gravity-fed
22 water filters prior to the invention?

23 A. Yes.

24 Q. And there were chemical and physical filtration
25 processes that were well known prior to the invention?

1 A. Yes.

2 Q. Okay. So activated carbon, that's one of the
3 most utilized ingredients in gravity-fed water filters prior
4 to the invention, right?

5 A. I would agree with that, yes.

6 Q. In fact, it was almost universally utilized in
7 gravity-fed water filters, right?

8 A. There were a lot of other materials utilized
9 also, but gravity, as you said, activated carbon is one of
10 the primary ingredients in a gravity-fed water filter.

11 Q. And it was well-known that filtration media like
12 activated carbon were often present in loose granular form,
13 right?

14 A. Yes.

15 Q. Okay. Ion exchange resins were often utilized in
16 drinking water, right?

17 A. Yes.

18 Q. And it was well known to use activated carbon and
19 ion exchange resins together in a single filter to achieve
20 better drinking water, right?

21 A. Yes.

22 Q. And it was well known prior to the invention how
23 to use physical barriers to filter out suspended particles
24 of a certain size, right?

25 A. Yes, well known.

1 Q. And that that included particulate lead, right?

2 A. What time frame are we talking about here?

3 Q. Prior to the invention, 2006.

4 A. I wouldn't necessarily agree with that, that it
5 was well-known. Many -- any material was well known to
6 removing particulate lead, no, I wouldn't agree with that.

7 Q. You wouldn't agree that it was also well known to
8 use physical barrier to filter out suspended particulates of
9 a certain size including particulate lead?

10 A. I said particulate -- I'm sorry. Particulates of
11 a certain size, but it wasn't well known as to what size
12 particulate lead was at a certain time.

13 Q. But you would agree it was well known to use a
14 physical barrier to filter out suspended particulates of a
15 certain size including particulate lead prior to the
16 invention.

17 A. I would say particulate -- in general,
18 particulates, but not necessarily particulate lead.

19 Q. So do you recall submitting an expert report in
20 this case?

21 A. Yes.

22 Q. You submitted two reports actually, right?

23 A. Yes.

24 Q. And you submitted an opening report where you
25 described the state of the prior art.

1 Do you recall that?

2 A. Yes.

3 Q. And you were truthful and accurate when you
4 submitted your expert report?

5 A. As much as I could be, yes.

6 Q. Okay. So could we go to Dr. Hatch's opening
7 report, PDF page 32. It's page 25 on the stamped copy.
8 Paragraph 100.

9 And this is your report -- first of all, I
10 apologize, before we get to that, do you see it says Expert
11 Report of Gary Hatch, Ph.D. Regarding the Invalidity of U.S.
12 Patent No. -- and I'm just going to say '141?

13 A. Yeah. Yes, I see that.

14 Q. And you remember writing a State of the Art
15 section for your report?

16 A. Yes, I do.

17 Q. And this is part of your State of the Art
18 section?

19 A. Yes.

20 Q. Okay. And you wrote at the time, it was also
21 well-known to use a physical barrier to filter out suspended
22 particulates of a certain size, including particulate lead.

23 Do you see that?

24 A. Yes, I do.

25 Q. And then, in fact, you go on to explain that you

1 had done this in your research at Pentair.

2 A. Yes, I did, of a certain size.

3 Q. Of particulate lead.

4 A. Certain size including particulate lead. It's
5 qualified by saying a certain size.

6 Q. We can pull this down.

7 Pleated paper filters were known before 2006,
8 right?

9 A. Yes.

10 Q. Well known?

11 A. Sure. It's one of the first things a beginning
12 chemist learns in class, to take a circular paper filter and
13 pleat it, fold it over and over until you create many pleats
14 and put it in the filter funnel.

15 Q. It was one of the first things a scientist
16 learns?

17 A. One of them, yes.

18 Q. Nano -- nonwovens were known prior to 2006 for
19 use in gravity-fed water filters?

20 A. Yes.

21 Q. Well known?

22 A. Yes, well known.

23 Q. Depth media was a known filtration technique
24 prior to 2006?

25 A. Yes.

1 Q. Nanofibers were a known filtration technique
2 prior to 2006?

3 A. Yes.

4 Q. Ligands were a known filtration technique prior
5 to 2006?

6 A. Certain ligands, yes.

7 Q. Zeolites were well known for use in gravity-fed
8 filters as early as the -- I apologize. I'm going to start
9 over.

10 Zeolites were well known for use in gravity-fed
11 filters as early as the early to mid 1990s, correct?

12 A. Yes.

13 Q. Now a person of ordinary skill, it was well known
14 that they would be able to configure these different types
15 of media that went into the filter cartridge, right?

16 A. In a general situation of making an ordinary
17 filter, yes.

18 Q. It was well known at the time that the
19 configuration of a gravity-fed filter cartridge could be
20 modified in order to achieve certain desired benefits,
21 right?

22 A. Excuse me. Are you citing from my opening
23 report, or is that just a general question from you?

24 Q. It is a question I would like you to confirm.

25 A. Okay.

1 Q. As to your opinion on the state of the art.

2 A. I'm sorry.

3 Q. Go ahead.

4 A. Yeah, I apologize, but, go ahead, ask the
5 question.

6 Q. It is your opinion that it was well known at the
7 time that configuration of a gravity-fed water filter
8 cartridge could be modified in order to achieve certain
9 desired benefits.

10 A. Yes, that's a good general statement.

11 Q. Okay. So let's talk about what could be
12 configured.

13 So a person of ordinary skill could configure the
14 shape and size of the cartridge, right?

15 A. Yes.

16 Q. They could configure the volume?

17 A. Yes.

18 Q. They can configure the composition of filtration
19 media?

20 A. Depending on what they wanted to accomplish, yes.

21 Q. And they could modify this in order to achieve
22 faster flow rates, right?

23 A. Depends on what you -- you might have to
24 compromise with regard to performance, but, typically, sure,
25 if you change faster flow rates, as I mentioned before, you

1 may compromise performance of another -- of another
2 situation.

3 Q. To be clear, Dr. Hatch, it is your opinion that
4 it was well known at the time -- that the configuration of a
5 gravity-fed water filter cartridge, for example, the size
6 and shape of cartridge, the volume and composition of
7 filtration media, and so forth, could be modified in order
8 to achieve certain desired benefits, such as faster flow
9 rate or improved contaminant reduction, right?

10 A. It's possible, yes.

11 Q. Is it possible or is it yes?

12 A. As I said, you have to weigh each of those
13 variables and consider the type of media you have to make
14 sure you're not compromising performance in any way. But
15 it's -- my answer is yes, it's possible.

16 Q. Dr. Hatch, you submitted, we talked about, an
17 opening report where you discuss the prior art, the state of
18 the prior art, right?

19 A. Yes.

20 Q. Let's go to paragraph 103 of that report.

21 Mr. Rennick, it's Dr. Hatch's opening report, PDF
22 page 33, document page 26.

23 Now, Dr. Hatch, in that report you say, it is
24 also well-known at the time that the configuration of a
25 gravity-fed water filter cartridge (for example, the shape

1 and size of the cartridge, the volume and composition of
2 filtration media, and so forth) could be modified in order
3 to achieve certain desired benefits, such as faster flow
4 rate or improved contaminant reduction.

5 Correct?

6 A. Yes, that's what I say.

7 Q. You did not qualify that statement, correct?

8 A. It's a general statement.

9 Q. You did not say that modifying one parameter
10 would affect performance of another, right?

11 A. I say it could be modified.

12 Q. Dr. Hatch --

13 A. Yes.

14 Q. -- in your opening report you did not say in the
15 state of the art that modifying one parameter would affect
16 the other parameter, right?

17 A. It's not mentioned here, but it's pretty obvious
18 for one skilled in the art to know that, especially in
19 filtration, that if you increase the flow rate you're going
20 to affect performance, or lower the volume, you're going to
21 affect performance. You just mentioned that a few minutes
22 ago.

23 Q. And you say nothing here about that the person of
24 ordinary skill would be unable to achieve their desired
25 benefits when they start to modify the variables, right?

1 A. A person skilled in the art, as we've defined
2 that person, with regard to trying to achieve what is
3 presented in the '141 patent and breadth of claims that are
4 in the '141 patent to make those modifications would, in my
5 opinion, a person of skill in the art would not be able to
6 understand how to achieve those changes and modifications
7 without undue experimentation.

8 Q. Dr. Hatch, I'm focusing on what you've said in
9 103 of your report. I repeated it correctly, right,
10 earlier, when we talked about it?

11 A. Yes.

12 Q. Okay. Thank you.

13 It's also your view -- we can take this down.

14 It's also your view that the patent admits it was
15 well-known how to optimize the filter -- these filter
16 performance criteria, right?

17 A. Is that in my report?

18 Q. I'm asking your opinion.

19 A. Oh. Repeat the question, please.

20 Q. In your view the patent admits that it was well
21 known how to optimize these filter performance
22 characteristics?

23 A. Is that cited somewhere that I said that, or are
24 you trying to ask me to confirm that?

25 Q. Dr. Hatch, is that your opinion today sitting

1 here today?

2 A. Please repeat that.

3 Q. Sure. In your view does the '141 patent admit
4 that it was well known to one of skill in the art how to
5 optimize these filter performance characteristics?

6 A. I wouldn't necessarily agree with that,
7 especially to achieve the breadth of claims in the patent.

8 Q. Mr. Rennick, could we go to Dr. Hatch's opening
9 report, paragraph 118, PDF 36, document page 29.

10 Dr. Hatch, in your opening report you say the
11 '141 patent also admits that it was well-known to one of
12 skill in the art how to optimize these filter performance
13 characteristics.

14 Do you see that?

15 A. I see that, yes.

16 Q. And you italicized and emphasized how to optimize
17 these filter performance characteristics, correct?

18 A. Give me a minute, could you please, so I can read
19 this?

20 Q. Sure.

21 JUDGE MCNAMARA: While we're waiting for
22 Dr. Hatch, please make sure that all of the sections that
23 you're using in Dr. Hatch's report are submitted as an
24 exhibit or marked as such and that they are put into the
25 record, please. Just make sure that the cover page of the

1 expert reports is also -- are also included.

2 MS. EVERETT: Yes, Your Honor.

3 A. Okay. Thank you, Your Honor.

4 Let me read that in yellow that you've
5 highlighted. It says, I'm stating here, I'm saying the '141
6 patent also admits that it is well-known to one of skill in
7 the art how to optimize these filter performance
8 characteristics.

9 Q. I don't want to interrupt in case there was more.
10 I couldn't tell if you were finished, Dr. Hatch.

11 A. Well, I'm still thinking about this. I think
12 what I'm saying is that the '141 patent says that it's
13 well-known, but I'm not so sure that I agree with that.

14 Q. So you disagree with the report -- strike that.
15 Dr. Hatch, we talked earlier today how you made
16 an effort to be truthful when you submitted your expert
17 reports.

18 A. Well --

19 Q. Yes?

20 A. Do you understand what I'm meaning here? I'm
21 just citing that it appears that the patent says that it's
22 well known for one skilled in the art for how to optimize
23 filter characteristics, that's what -- that's what the
24 patent says, right?

25 Q. And --

1 A. It says the '141 patent also admits that it is
2 well known. So the inventors are saying it's well known
3 that a person of skill in the art to optimize filter
4 performance characteristics. I don't necessarily agree with
5 that, that it's well known.

6 Q. Dr. Hatch, this is your State of the Art section.

7 JUDGE MCNAMARA: Ms. Everett, I don't mean to --
8 well, I do -- I think you need to move on. I think --

9 Dr. Hatch, if I understand correctly, all you did
10 in 118 was say that -- exactly what the patent says,
11 correct?

12 THE WITNESS: Yes.

13 JUDGE MCNAMARA: And now you're saying you don't
14 necessarily agree with the content of that statement or the
15 conclusion of that statement; is that accurate?

16 THE WITNESS: Well, I just made a statement
17 there, and what I'm saying is that apparently in the '141
18 patent the inventors say that it's well known to one skilled
19 in the art how to optimize filter performance
20 characteristics. That's --

21 JUDGE MCNAMARA: And all you're saying is that's
22 a statement, but you don't necessarily agree with the
23 content of that statement.

24 THE WITNESS: Exactly. Exactly. Thank you.

25 JUDGE MCNAMARA: Thank you.

1 THE WITNESS: Thank you.

2 Q. Dr. Hatch, you go on to identify two portions of
3 the patent that describe how to modify the performance
4 characteristics, correct?

5 A. Yes.

6 Q. And after your review of the patent, you
7 determined, column 3, line 51, to column 5, line 21,
8 describe how a loose media/granular filter may be modified
9 in order to optimize flow rate, volume, contaminant removal,
10 and filter capacity, right?

11 A. Yes.

12 Q. And after your review of the patent you
13 determined that column 1, lines 64 to column 2, line 52
14 describe how a prior art cylindrical filter could be
15 modified in order to optimize flow rate, volume, contaminant
16 removal, and filter capacity.

17 A. Yes.

18 MS. EVERETT: I have no further questions.

19 JUDGE MCNAMARA: All right. Thank you.

20 Mr. Davison, do you have any redirect?

21 MR. DAVISON: I do have a couple brief questions,
22 Your Honor, if I may.

23 JUDGE MCNAMARA: Sure.

24

25

1 REDIRECT EXAMINATION

2 BY MR. DAVISON:

3 Q. Dr. Hatch, let's go back and reset ourselves.

4 The working examples of the '141 patent, are the
5 only working examples of filters that meet the limitations
6 of the asserted claims carbon block?

7 A. Yes.

8 Q. Okay. Brita's counsel walked you through a
9 number of sections of the '141 patent on cross.

10 Did you consider the entirety of the '141 patent
11 when you formed your opinions?

12 A. Yes, I did.

13 Q. So were there any sections that you just ignored?

14 A. Oh, no.

15 Q. So you considered the portions of the '141 patent
16 beyond the working examples?

17 A. Yes.

18 MR. DAVISON: I have no further questions,
19 Your Honor.

20 JUDGE MCNAMARA: Okay. Ms. Everett, do you have
21 any recross examination?

22 MS. EVERETT: I don't, Your Honor.

23 JUDGE MCNAMARA: All right. I just have a couple
24 of questions.

25 Thank you, Ms. Everett.

1 BY JUDGE MCNAMARA:

2 Q. I have a couple questions for you, Dr. Hatch.

3 A. Yes.

4 Q. Are you testifying here today on behalf of all
5 three remaining Respondents or only on behalf of PUR?

6 A. I'm not sure, Your Honor, but I think I'm
7 testifying here really for all three defendants.

8 MR. DAVISON: Your Honor, if I may, I can confirm
9 that that is how he was engaged.

10 JUDGE MCNAMARA: Thank you. I appreciate that.

11 Q. Did you construe -- early on this morning at
12 about 10 a.m. Mr. Davison asked you about the application of
13 plain and ordinary meaning to claims. Did you actually
14 construe -- I'm sorry.

15 Did you raise any terms for construction here
16 today in your testimony that were not otherwise contained in
17 the Markman order that you reviewed?

18 A. Oh, I'm not aware that I did. I --

19 Q. So why did you offer the opinion that you applied
20 plain and ordinary meaning since you were not offered to
21 construe or you were not asked for claim construction on any
22 other terms or on any terms? There's a Markman order that
23 construed claim terms, so do you know why you were asked
24 whether or not you applied plain and ordinary meaning to any
25 claim terms today?

1 A. I don't quite understand the question. Could
2 you --

3 Q. In your testimony you said that you applied the
4 plain and ordinary meaning to claim terms, but you weren't
5 given any claim terms to which -- to which plain and
6 ordinary meaning were applied. So were you offering any
7 claim terms for construction this morning to which you're
8 saying plain and ordinary meaning applied?

9 A. I believe we talked about the -- was it filter
10 life?

11 Q. You didn't give a meaning of the term filter life
12 this morning, did you, beyond the scope of the patent?

13 A. No. No, I'm sorry, I don't recall. I'm sorry.
14 I don't recall.

15 Q. Okay.

16 JUDGE MCNAMARA: I think those are my questions,
17 and I think you answered the question about what undue
18 experimentation is, as much as I think you were able to.

19 All right. If there's nothing more, then thank
20 you, Dr. Hatch, you can step down for the time being.

21 THE WITNESS: Thank you very much, Your Honor.

22 JUDGE MCNAMARA: All right. So it is 12:15.
23 What would you like to do? Would you like to break now for
24 lunch, or how much time -- you're going to call Dr. Freeman,
25 correct? You're on mute.

1 MR. AINSWORTH: I apologize, Your Honor. Yes,
2 we'll be calling Dr. Freeman next. If Your Honor is open to
3 it, I think take lunch now and then start with Dr. Freeman
4 after lunch?

5 JUDGE MCNAMARA: Yep. So I'll see you back here
6 at 1:15.

7 MR. AINSWORTH: Wonderful. Thank you.

8 MR. DAVISON: Thank you.

9 (Whereupon, the proceedings recessed at 12:15
10 p.m.)

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1 AFTERNOON SESSION

2 (In session at 1:20 p.m.)

3 JUDGE MCNAMARA: Good afternoon everybody. Sorry
4 for the delay. Seems like I was having computer problems.
5 My computer decided it was just time to update all of my
6 files, what can I tell you. I'm not in control of that, so
7 there you go.

8 MR. AINSWORTH: We all know that feeling,
9 Your Honor.

10 JUDGE MCNAMARA: Yeah, I'm sure you do.

11 All right. Good afternoon again. I guess we are
12 ready now at this point to start the examination of
13 Dr. Benny Freeman.

14 Is that correct, Mr. Swain? And I gather you're
15 doing that.

16 MR. SWAIN: I will eventually, Your Honor, but I
17 believe Mr. Ainsworth will be handling his direct testimony.

18 JUDGE MCNAMARA: Of course. I'm so sorry.

19 Mr. Ainsworth, are you ready to start after I
20 administer the oath? Is there anything you'd like to
21 mention before we get going?

22 MR. AINSWORTH: Nothing else, Your Honor. Thank
23 you.

24

25

1 JUDGE MCNAMARA: Good afternoon, Dr. Freeman.
2 Would you please raise your right hand.

3 BENNY DEAN FREEMAN,
4 having been first duly sworn and/or affirmed
5 on his oath, was thereafter examined and testified as
6 follows:

7 JUDGE MCNAMARA: Please state your name.

8 THE WITNESS: Benny Dean Freeman.

9 JUDGE MCNAMARA: All right. Thank you very much.
10 Mr. Ainsworth, the floor is yours.

11 MR. AINSWORTH: Thank you, Your Honor.

12 DIRECT EXAMINATION

13 BY MR. AINSWORTH:

14 Q. Good afternoon, Dr. Freeman. Have you prepared
15 some demonstratives to assist with your testimony today?

16 A. I have.

17 Q. Mr. Rennick, if we could please bring up CDX-2.
18 Doctor, are these your demonstratives?

19 A. They are.

20 Q. Dr. Freeman, would you please summarize for the
21 Court your educational background?

22 A. So I, after high school, I went to North Carolina
23 State University, and I graduated with a BS degree in
24 chemical engineering in 1983, and I went afterwards to the
25 University of California, Berkeley, and I received my Ph.D.

1 in chemical engineering in 1988.

2 Q. Doctor, after completing your Ph.D., what did you
3 do next?

4 A. I went on to a postdoctoral fellowship, NATO
5 postdoctoral fellowship at a laboratory in France, and I
6 think the next slide has that information.

7 Q. CDX-2.3.

8 A. And so I was a postdoctoral fellow at this
9 laboratory from March of 1988 until July '89.

10 Q. And after completing your postdoctoral
11 fellowship, what did you do next, doctor?

12 A. I came back to my undergraduate alma mater to NC
13 State and I started as an assistant professor of chemical
14 engineering there.

15 Q. What were your responsibilities as an assistant
16 professor of chemical engineering at NC State?

17 A. Broadly in three categories. So teaching at both
18 the undergraduate and graduate level, research, I started my
19 research program, my independent research program there, and
20 then service to the institution and the profession.

21 Q. What types of subject matter did you teach in
22 coursework at NC State as a professor?

23 A. So I taught chemical engineering, basic
24 principles, separations, thermodynamics, I taught the unit
25 operations laboratory, I taught graduate level courses in

1 polymer science and in separations and several others, but
2 those are some of the main ones.

3 Q. In terms of your research while at NC State, what
4 was the focus of that?

5 A. So my research is in the area of filtration and
6 mainly in membrane filtration, although we do some work as
7 well with absorbents, and we focused on filtration of gases
8 and liquids.

9 Q. And how long were you at NC State?

10 A. I was there until January of 2002.

11 Q. Before you left NC State, were you ultimately
12 promoted to full professor?

13 A. I was, yes.

14 Q. Where did you go after NC State?

15 A. In January 2002 I moved to the University of
16 Texas at Austin and joined the chemical engineering faculty
17 there.

18 Q. And what were your responsibilities at the
19 University of Texas?

20 A. It's in the same broad category, so I am teaching
21 at the undergraduate and graduate levels. I have a research
22 program that I run, and I also provide service to the
23 institution and to the profession in general.

24 Q. In terms of your research, both at University of
25 Texas as well as back at NC State, what sort of research did

1 you do with respect to water purification specifically?

2 A. So we've been working in this field for, gosh, I
3 guess a little over 30 years now, and we've studied the
4 membrane fouling, we studied the use of absorbents to change
5 the properties of separation properties of filters, we
6 designed new types of filters for water purification, such
7 as ion separations and desalination, and we also have an
8 effort focused on manufacturing of membrane filters.

9 Q. What experience do you have with gravity-fed
10 filtering equipment?

11 A. So beginning at the -- at the beginning of my
12 career and even as an undergraduate, gravity-fed equipment
13 for separations and other applications is a core part of
14 chemical engineering, because it's widely used in the
15 profession, and so I would have been doing experiments and
16 studying the design of gravity-fed separation systems as an
17 undergraduate.

18 I would then have been teaching that as a faculty
19 member, and also when I direct the unit operations
20 laboratory we have a working version of that sort of device
21 that we use to train the students in that area.

22 Q. Has any of your work involved commercial water
23 filtration products?

24 A. Yes. So we often use commercial water filtration
25 products in our research, and, as part of our research, we

1 have made discoveries that have led to commercial water
2 filtration products. One was the discovery of coatings that
3 can be applied to virtually any water treatment filter that
4 reduced its tendency to foul or to get dirty when you're
5 filtering water with contaminants in it. And those filters
6 are now sold by a company in the Chicago area.

7 We also have recently launched a startup company
8 in the Austin area that is focused on using technology for
9 our laboratory to remove lithium from water as part of
10 extracting lithium for battery manufacture.

11 Q. In addition to your professorship at the
12 University of Texas, what other positions do you currently
13 hold?

14 A. So I also chair or direct a research center for
15 the United States Department of Energy. It's one of their
16 energy frontier research centers. These are their basic
17 science research centers. And my center is in the area of
18 novel materials for membranes and absorbents for water
19 purification. I have about 60 team members in that center
20 over -- at three different institutions. Our home
21 institution is in Texas and two out in California.

22 Q. If we could go to the next slide, slide 4,
23 Mr. Rennick.

24 Dr. Freeman, are you a member of any industry
25 groups?

1 A. Yes. As part of the service to the profession,
2 I've served in many technical organizations, such as the
3 American Chemical Society, the American institute of
4 chemical engineers, and the North American membrane society.

5 I've served for more than 25 years on the
6 executive committee of the Polymeric Material Science and
7 Engineering Division of the American Chemical Society. I've
8 held leadership roles in many of these professional
9 societies. I've been president of the North American
10 Membrane Society.

11 I've led the separations division of the American
12 Chemical Society -- of the American institute of chemical
13 engineers, and I've been named a fellow of several
14 organizations, including the North American Membrane
15 Society, the American Association for the Advancement of
16 Science, American institute of chemical engineers, the
17 American Chemical Society.

18 Q. Have you published any books or articles in your
19 field?

20 A. I have. Together with my colleagues and
21 students, we published now just over five hundred
22 publications, and I've edited five books in this area.

23 Q. And are you a named inventor on any patents?

24 A. Yes, I'm a named inventor on now 23 issued U.S.
25 and international patents.

1 Q. Mr. Rennick, slide 5, please.

2 Dr. Freeman, what awards have you received or
3 recognition have you received for your work in the field?

4 A. On this slide are listed a few of them. So the
5 Reilly Lectureship at Notre Dame and the Byrd, Stewart and
6 Lightfoot lecture at the University of Wisconsin were in
7 recognition of my work in water purification filters, as was
8 the Fulbright Distinguished Chair in disruptive separations.
9 The Joe J. King Award at the University of Texas is the
10 highest general engineering research award that the
11 university offers, and it was also for my work in novel
12 filtration membranes. The Clarence Gerhold Award from the
13 American Institute of Chemical Engineers was for separations
14 research. And the American Chemical Society's National
15 Award in applied polymer science was for my work in
16 separations and filters.

17 Q. Doctor, do you hold any professional licenses?

18 A. I'm a registered professional engineer in the
19 state of Texas.

20 Q. Mr. Rennick, could you please bring up CX-343.

21 Dr. Freeman, do you recognize Exhibit CX-343?

22 A. Yes, sir. It appears to be my CV.

23 Q. And does your CV contain an accurate summary of
24 your professional qualifications?

25 A. Yes, sir, it does.

1 MR. AINSWORTH: Your Honor, at this time we
2 submit Dr. Benny Freeman as an expert in the field of
3 chemical engineering, polymer science technology, and water
4 purification.

5 JUDGE MCNAMARA: Mr. Swain, do the Respondents
6 have any objections to Dr. Freeman being admitted as an
7 expert on the topics for which he has been offered?

8 MR. SWAIN: No objections, Your Honor.

9 JUDGE MCNAMARA: Thank you. Then Dr. Freeman is
10 admitted as an expert on the topics for which he has been
11 offered as an expert.

12 MR. AINSWORTH: Thank you, Your Honor.

13 Q. Dr. Freeman, have you reviewed the '141 patent?

14 A. Yes, sir, I have.

15 Q. And what is your, at a high level, understanding
16 of the subject matter of the '141 patent?

17 A. So it's directed towards gravity flow water
18 filters that have good performance for removing lead and
19 fast flow rates, so it's improvement in water filter
20 technology for gravity-fed water filters.

21 Q. CDX-2, slide 6, please.

22 Mr. Freeman, are you aware that the
23 administrative law judge has adopted a definition of what a
24 person of ordinary skill in the art is for purposes of this
25 investigation?

1 A. Yes, I am.

2 Q. Next slide, please, Mr. Rennick.

3 And we're now on slide CDX-2.7.

4 Dr. Freeman, is this the definition of a person
5 of ordinary skill in the art that you understand that the
6 ALJ has adopted for this investigation?

7 A. Yes, sir, that's my understanding.

8 Q. And for your opinions that you're providing
9 today, is this the definition that you are applying?

10 A. Yes, sir.

11 Q. At the time of the invention did you have at
12 least the level of ordinary skill in the art as defined by
13 the administrative law judge?

14 A. Yes, sir.

15 Q. Doctor, how does the definition of a person of
16 ordinary skill in the art in this investigation inform the
17 opinions that you'll be providing today?

18 A. So it gives the background into what one could
19 expect a person of ordinary skill to know, what skills they
20 would have, and be able to bring to bear on the subject
21 matter of the '141 patent.

22 Q. Now if we can go back to slide 6, please.

23 For purposes of your opinions in this case,
24 Dr. Freeman, what is your understanding of the relevant time
25 frame for your analysis of the state of the art pertinent to

1 the '141 patent?

2 A. My understanding, it's in the 2006 to 2008 time
3 frame.

4 Q. Before we dive into your opinions and into the
5 '141 patent in more detail, could you explain -- let's talk
6 about the state of the art for a moment.

7 Were gravity-fed water filters considered a
8 nascent technology prior to 2008?

9 A. No. This technology has been around for decades,
10 if not generations. It would have been one of the earliest
11 ways that water filtration would have been accomplished.

12 Q. And at the time of the invention, what types of
13 filter media were known in the art?

14 A. So there were a lot of types of filter media,
15 things like nonwovens, there were the block filters,
16 membrane filters, nanofiber filters, and several other
17 mixed-media filters, several other classes of filters were
18 well-known.

19 Q. Now let's turn to the '141 patent. If we go to
20 slide 8 of CDX-2, so 2.8, please.

21 What does the '141 patent describe with respect
22 to the state of the prior art at the time of the invention?

23 A. So this is some examples from the specification
24 in the background to the '141 patent. For example, at
25 column 1, lines 26-30, it notes that several different

1 methods are known for filtration of water, and various
2 devices and apparatus have been designed and are
3 commercially available.

4 At column 1, lines 53-57 it says that gravity
5 flow filtration systems are well-known in the art. And then
6 it gives some examples in the specification of different
7 known filter types.

8 One, at column 2, lines 53-60 are corrugated
9 filter sheets for air filtration, and at column 3, lines
10 24-29, it notes granular activated carbon media for water
11 filtration.

12 Q. Now you mentioned the example from column 2, line
13 53-60 describing corrugated filter sheets for air
14 filtration.

15 Why are media used in air filtration relevant to
16 gravity-fed water filter?

17 A. Well, the basic scientific principles that govern
18 the flow of air through these types of corrugated filters
19 and the removal of particulates from it are exactly the same
20 basic science principles that govern the flow of water
21 through such a filter and the removal of particulates from
22 that water.

23 And so a person of ordinary skill in the art
24 could learn from the art on corrugated filter sheets for air
25 filtration, and apply that learning to a similar -- a

1 similar sort of filter for water purification.

2 Q. We can take the demonstratives down for a moment.

3 Now at the time of the '141 patent, how would you
4 characterize the volume and level of resources and
5 literature available to a person of ordinary skill in the
6 art interested in gravity-fed water filters?

7 A. So there would have been an enormous amount of
8 information available to a person of skill in the art at
9 this time. So there were a very, very large number of
10 research articles in the scientific literature. There were
11 handbooks and books published on this topic.

12 There would have been scientific conferences
13 going on for a person of ordinary skill in the art could
14 learn more about the state of the art. And, of course,
15 there's all of the patent literature as well that was
16 available. So it's really a vast amount of information that
17 was available.

18 Q. Mr. Rennick, if you could bring up CX-842.

19 Doctor, do you recognize CX-842?

20 A. Yes, sir. This is the Handbook of Filter Media,
21 and it would -- it's a handbook that would have been
22 available to a person of ordinary skill during the time
23 frame of interest.

24 Q. Do you recall what year this particular book was
25 published?

1 A. I believe it was -- it was before 2006, and it
2 says in the copyright page it was 2002.

3 Q. Okay. At a high level, what is a handbook? What
4 does that denote?

5 A. So a handbook is a compilation of known
6 information or a subset of known information about a given
7 topic, in this case filter media.

8 And so when people prepare handbooks, they draw
9 from what's already known in the art and they aggregate that
10 information and organize it to make it easier to search and
11 to often put it into broader context. So this would have
12 taught what was existing in the state of the art at the time
13 the handbook was published.

14 They also often give some historical background
15 to how the field got to a certain place.

16 Q. Now in this exhibit I think you selected one
17 particular chapter. If we could go to chapter 8. We're on
18 842 at page 4.

19 What chapter did you select here for illustrative
20 purposes, doctor?

21 A. So chapter 8 is a chapter on filtration by
22 membrane filters, and it talks a lot about how these filters
23 are designed, what their structure is, the sorts of
24 separations and filtration that can be done with them and so
25 forth.

1 Q. And how would a person of skill in the art use
2 information such as is available in the Handbook of Filter
3 Media to design a gravity-fed water filter?

4 A. So the information that is, for example, in this
5 chapter would provide an introduction to a lot of the
6 methods in which these membrane filters are used for a
7 filtration application, like water purification and
8 desalting or removal of ions from water. And they would
9 also provide a series of references to other earlier work,
10 including other handbooks that a person of skill in the art
11 could reference for more details about any given topic.

12 Q. If we could go to CX-843.

13 And we're on CX-843 at page 2.

14 Do you recognize this exhibit, doctor?

15 A. Yes. This is a Handbook of Nonwoven Filter
16 Media.

17 Q. And what year was this particular text available?

18 A. It was available -- perhaps one more page -- the
19 first edition was published in 2007, and this is the first
20 edition of that handbook.

21 Q. So what information is provided in this
22 particular handbook at a high level?

23 A. Yes. So if we go forward to the Table of
24 Contents, it gives information about a large variety of
25 nonwoven filter media, and you can see the various types

1 that are set forth. It talks about how to make nonwoven
2 filter media and how to use them. It talks about the theory
3 behind filtration mechanisms and separation. And it goes
4 into more detail later on about the physical properties of
5 nonwoven filter media.

6 And, ultimately, it talks about, in later
7 chapters, about how the -- what you make these materials out
8 of and then how they're used in applications, including gas
9 filtration applications as well as liquid filtration
10 applications.

11 So it's about 400-and-some-odd pages of
12 information just on non woven filter media.

13 Q. If a person of skill in the art was interested in
14 making a gravity-fed water filter with a nonwoven filter
15 media, how would they use information that was found in
16 Exhibit 843?

17 A. So a handbook like this would provide a lot of
18 information about what the nonwoven media were made of, how
19 they were made, what their physical properties were, what
20 their filtration properties were. There would be
21 information in here about where to get them, and the way
22 that they could be modified to change their properties and
23 would give illustrious examples of how nonwoven filter media
24 are used in the field.

25 Q. How would information available in, say, the

1 Handbook of Nonwoven Filter Media be useful or applicable to
2 a skilled artisan looking to apply those concepts to other
3 filter media formats?

4 A. So they would -- it would be useful because the
5 way that -- there's a couple of ways that these sorts of
6 filters actually achieve filtration.

7 One is they are porous, and so fluids like water
8 pass through them, and the pore size determines what size
9 particulates get retained. And that sort of information
10 would be useful to a person of ordinary skill as they look
11 to design other types of filter media.

12 There's also a lot of discussion about components
13 that can be added to these nonwoven filter media, like
14 carbon, activated carbon, and also other chemical species to
15 perform chemical separation, such as ion absorption, and
16 that sort of information would be useful to a person of
17 skill in the art looking to use those sorts of materials in
18 other formats or other media.

19 Q. Mr. Rennick, CX-836, please.

20 Doctor, do you recognize Exhibit CX-836?

21 A. Yes. This is a research article published in the
22 journal Polymer, which is the journal I'm editor-in-chief
23 of. And -- in 2004. And it's giving a discussion of how to
24 make nano fibrous, nonwoven mats by electrospinning, and it
25 lays out the details of how to form such nano fibrous

1 nonwoven mats, and it discusses their potential use in
2 applications that include filter, filters.

3 JUDGE MCNAMARA: Pardon me, Mr. Allison -- I'm
4 sorry, Mr. Ainsworth, sorry about that. Can you give me the
5 exhibit number again, please, of Polymer?

6 MR. AINSWORTH: Yes, Your Honor. It's CX-836.

7 JUDGE MCNAMARA: Thank you.

8 Q. Mr. Rennick, if we could go to RX-631 now,
9 please.

10 Dr. Freeman, do you recognize RX-631?

11 A. Yes, sir. This is a U.S. Patent application
12 publication to Rinker, et al.

13 Q. And when was the Rinker application published?

14 A. January 5th, 2006.

15 Q. And what is described and disclosed in the Rinker
16 application?

17 A. So Rinker, as we see in the abstract, is
18 disclosing a gravity flow carbon block filters, and it talks
19 about having activated carbon filters and how you hold those
20 together with a binder that's a polymer, and it discuss the
21 filtration properties of these filters. It also discusses
22 other types of filter media as well.

23 Q. What other types of filter media are described in
24 the Rinker application?

25 A. I believe a bit further down we see filter

1 sheets, for example.

2 Q. If we could go to page 18 of RX-631.

3 A. Yeah, so this is, at paragraph 66, this is
4 discussing how filter sheets can be used with porous carbon
5 blocks, and it talks about how one might apply those filter
6 sheets inside or outside of the block, and the filter sheet
7 can be a nonwoven material, and it gives pore size, pore
8 size for a filter to remove biological contaminants such as
9 Giardia and Cryptosporidium. It also talks about the use of
10 these filter sheets in conjunction with carbon blocks, and
11 it says they can improve the performance of carbon blocks
12 potentially.

13 Q. And this may be obvious, Dr. Freeman, but a
14 filter sheet, can that be a type of nonwoven material?

15 A. Yes, that's correct, and you'll see that down a
16 few lines here where it says in one embodiment, for example,
17 the filter sheet 24 is a nonwoven material with a 1.0 micron
18 pore size.

19 Q. Does the '141 patent refer to the Rinker
20 application in its specification?

21 A. Yes, the '141 patent I believe incorporates this
22 reference.

23 Q. Mr. Rennick, if we could bring up JX-22, the '141
24 patent, at page 39. And go to column 17, lines 4-7.

25 So what does the '141 patent tell us about

1 looking to Rinker for?

2 A. It says additional components and features, and
3 it's talking about the filters that are being described in
4 this -- in the one. It says additional components and
5 features may also be present, such as filter sheets, as
6 described in U.S. Patent application, and then it gives the
7 number for the Rinker, et al. and it says which is herein
8 incorporated by reference.

9 Q. Thank you. You can take that down for now.

10 Now we've talked about nonwovens and we've talked
11 about membranes and we've talked about nanofibers.

12 Were filter media -- I'm sorry. Was there
13 literature available to a person skilled in the art
14 concerning nanoparticles used in filter media?

15 A. Sure. There would have been a large literature
16 for the use of nanoparticles in the filtration, and
17 nanoparticles and nanofibers goes back a long time.

18 Q. What about depth media?

19 A. Yes, depth media filters have been around, again,
20 for decades at least.

21 Q. And what about ligands?

22 A. Yes, ligand-based filtration is a very old
23 concept in chemistry.

24 Q. So as of the date of the invention, the '141
25 patent, how would you characterize the state of the art and

1 level of information available to a person of skill in the
2 art?

3 A. The field was well developed. It was widely
4 practiced. And there was an enormous amount of information
5 that would be available to a person of skill in the art to
6 assist them in filter design and filter making and then
7 ultimately filter testing.

8 Q. Thank you, doctor.

9 Now, Mr. Rennick, demonstrative CDX-2 and let's
10 go to slide 9, please.

11 Doctor, are you familiar with the asserted claims
12 in this investigation?

13 A. Yes, sir.

14 Q. And are these shown on slide 9?

15 A. Yes, sir, these are claims 1 through 6 and 23.

16 Q. Have you also reviewed the Markman order issued
17 by the administrative law judge in this case?

18 A. I have.

19 Q. Slide 10, Mr. Rennick.

20 Now at the time you issued your two reports in
21 this investigation, had the administrative law judge issued
22 her claim construction decision at that point?

23 A. Not yet, that was still pending.

24 Q. And the opinions you're expressing here today,
25 are you relying upon the claim constructions adopted by the

1 administrative law judge?

2 A. Yes, I am.

3 Q. If we can now turn to slide 11, Mr. Rennick.

4 Doctor, could you please summarize the opinions
5 that you'll be testifying to today?

6 A. So my opinions are summarized on this slide.
7 I'll be offering opinions that the '141 patent does not lack
8 written description and does not lack enablement, that the
9 asserted claims are directed to an article of manufacture
10 and are improvements over prior art filters, and that the
11 '141 patent does not unduly preempt commercial gravity-fed
12 water filters, that the invention was conceived by a basics
13 team in 2006 and reduced to practice through July and August
14 of 2006, and that the '141 patent is entitled to the benefit
15 of the priority date of the '372 application.

16 Q. Thank you, doctor.

17 So let's turn to your first opinions.

18 Do you understand that you are offering
19 opinions in your testimony today in rebuttal to the
20 testimony of Dr. Hatch?

21 A. That's my understanding.

22 Q. And you were present for Dr. Hatch's testimony?

23 A. Yes, sir.

24 Q. And did you hear Dr. Hatch testify that he did
25 not believe that the '141 patent provided written

1 description support for the asserted claims in this
2 investigation?

3 A. I did.

4 Q. Do you agree with that opinion?

5 A. No, I do not.

6 Q. Why not?

7 A. Well, I think that the '141 patent does provide
8 adequate written description to enable a person of skill in
9 the art to understand that the inventors had possession of
10 the invention.

11 Q. If we could go to slide 12.

12 And let's start with claim 1, Dr. Freeman.

13 Can you explain where you find support in the
14 specification of the '141 patent for claim 1?

15 A. Yes. So the support for that or one place for
16 support for that is at column 12, lines 9-28, and it says,
17 in a further embodiment of the present invention a
18 gravity-fed water filter block or granular includes filter
19 media including at least activated carbon and a lead
20 scavenger. The filter achieves a Filter Rate and
21 Performance or FRAP factor of about 350 or less according to
22 the following formula.

23 It defines the variables that go into the FRAP
24 equation, and gives the specification for the challenge
25 water or influent water that should be used in testing the

1 filter, and this lines up perfectly with the way that
2 information is presented in claim 1.

3 Q. Is there further support in the specification for
4 the subject matter of claim 1?

5 A. Yes. Yes, sir.

6 Q. Slide 13.

7 What is shown in slide 13, doctor?

8 A. So slide 13 has, in the Table 1, has examples of
9 some filters that were made and then tested. And one of
10 the -- one of the components of claim 1 is that the filters
11 have to have at least a lead sorbent and activated carbon,
12 and each of these filters has a lead sorbent, that's given
13 in the second column, and they also have a carbon type that
14 is PAC, which we see in the footnote is powder activated
15 carbon. So all of these examples have both activated carbon
16 and a lead sorbent or lead scavenger, and that's consistent
17 with the preamble of claim 1 from the beginning of claim 1.

18 Q. Dr. Freeman, if you look at the last two
19 examples, just to clarify, do those two examples, P2-8 and
20 P2-6, have a lead sorbent?

21 A. These two do not. All the others were prepared
22 with both a lead sorbent and activated carbon.

23 Q. Are you aware of any dispute that the -- from
24 Respondents or Dr. Hatch -- that the working examples,
25 except for the last two we just talked about in table 1, are

1 embodiments of claim 1?

2 A. No, I'm not.

3 Q. If we could go to slide 14, please.

4 Doctor, what is shown on slide 14?

5 A. So on the left-hand side is Table 5, which we've
6 seen earlier today, which shows some of the filters that
7 were made and tested in the '141. And what's on the right
8 is a chart or a table that I prepared where I've excerpted
9 filters from Table 5 that achieve the FRAP factor below 350.
10 Those are the ones shown in green at the top of this table.

11 And the ones that are shown at the bottom below
12 the heavy horizontal line are prior art conventional
13 filters.

14 Q. If we turn to slide 15, please.

15 Can you explain -- well, what is slide 15?

16 A. So slide 15 is a demonstrative that I made, which
17 shows a plot of the effluent lead concentration at the end
18 of the lifetime of the filter for various filters that we
19 saw in the previous table. Above each of the blue dots is
20 the FRAP factor value. And you can see that the filters
21 that have a FRAP of less than 350 and lead levels of less
22 than about 10 micrograms per liter or 10 ppb are
23 differentiated from the ones to the right of that vertical
24 black line, which are the prior art conventional filters
25 that all have a high effluent lead concentration and are

1 above the FRAP factor of 350.

2 Q. Now, doctor, does the '141 patent specification
3 provide working examples of work embodiments that have FRAP
4 factors along the entire range from of about 350 or less?

5 A. Yes.

6 Q. I'm sorry. Is there working examples for every
7 point on the line?

8 A. No, there are not working examples for every
9 point along the line, that's correct.

10 Q. So would a skilled artisan need to see working
11 embodiments for every point on the range of about 350 or
12 less in order to understand that the inventors had
13 possession of their claimed invention?

14 A. No, they would not. A skilled artisan would know
15 from the working examples plus other information in the
16 specification that the inventors had possession of the
17 invention.

18 Q. Let's turn to some of the other information in
19 the '141 patent. And if we could turn to slide 16.

20 Now slide 16 is showing -- what is it showing,
21 doctor?

22 A. So this is a graph that the inventors prepared,
23 and what it's showing is the interrelationship between some
24 of the variables and the FRAP factor.

25 In this case it's showing what happens to the

1 FRAP factor as the filtration unit time changes and as the
2 volume of the filter changes, and that the point that the
3 inventors are making was that if you could make a filter
4 that had -- that had higher volume and longer filtration
5 time, that those attributes would tend to increase the FRAP
6 factor and vice versa.

7 These values or parameters are interrelated
8 because they depend upon the nature of the filter, how it's
9 disposed, and so forth, but this is showing a relationship
10 between those variables.

11 Q. And what does Fig. 21 disclose to a person of
12 skill in the art about what the inventors were disclosing
13 with respect to the filtration rate of their invention?

14 A. Well, they were -- here they're presenting these
15 calculations at filtration rates from, I guess, about two
16 minutes per liter up to out past 20 minutes per liter, and
17 they are showing how, if you could hold all the other
18 variables constant, the filtration rate would affect the
19 FRAP value, and then at various volumes of filter media how
20 that would change the FRAP factor as well.

21 Q. And did you hear any testimony from Dr. Hatch
22 about Fig. 21?

23 A. Yes, I believe I did.

24 Q. And how did he factor that into his opinions?

25 A. It didn't seem like it factored very much into

1 his opinions as far as I could tell.

2 Q. If we could turn to the next slide, slide 17.

3 What is shown on slide 17, doctor?

4 A. So this is showing, again, some of the
5 interrelationships between the variables that contribute to
6 the FRAP factor, and in this case it's how the filtration
7 unit time or flow rate, if you will, and the effluent lead
8 concentration impact the FRAP factor, and they're showing
9 that, as you change the filtration unit time, that that
10 can -- you can also move the outlet lead concentration, and
11 those can have an impact on the FRAP factor.

12 Q. If we could go to the next slide.

13 So we're on CDX-2, slide 18.

14 What is shown on this slide?

15 A. This is showing the FRAP factor and how it
16 changes with filtration unit volume and now with the
17 lifetime of the filter. And what it's showing is that you
18 could have a variety of FRAP factors depending on the
19 interplay of the lifetime and filtration rate.

20 Q. If we could bring up CX-139.

21 Doctor, do you recognize CX-139?

22 A. Yes, sir. This is, to my understanding, a
23 document that Elizabeth Knipmeyer of Brita prepared in about
24 September 2006.

25 Q. And did the Court hear testimony from

1 Dr. Knipmeyer on this document back in the August part of
2 the hearing?

3 A. Yes, we did.

4 Q. And we may come back to this a little later, but,
5 in general, what is being described in Dr. Knipmeyer's
6 document here?

7 A. So this is where Dr. Knipmeyer wrote down the
8 equation for the FRAP factor and including the variables of
9 filter volume, average filtration unit time, end of life
10 effluent lead concentration, and filter usage lifetime, and
11 had shown how these are interrelated with one another to
12 give a number, a FRAP number, that could characterize the
13 overall performance of a given filter.

14 Q. And if we turn to page 2 of Exhibit 139, what is
15 shown on page 2 of Exhibit 139?

16 A. So these are -- these are the graphs that have
17 the same information as those that ultimately appear in the
18 '141 patent, the ones we were looking at just a moment ago.

19 Q. If we turn to slide 3, will we see that third
20 figure there as well that we were talking about earlier?

21 A. Yes, that's correct.

22 Q. Back in September of 2006 Dr. Knipmeyer had
23 described -- what does it show that Dr. Knipmeyer
24 appreciated back in September of 2006?

25 A. Oh, that she appreciated the interrelationship

1 between these variables and also the way that they would
2 influence the FRAP value and also that she had in mind this
3 FRAP value of 350.

4 Q. Now if we could go to slide 19, so back to the
5 demonstratives, CDX-2, slide 19.

6 What is shown on slide 19, Dr. Freeman?

7 A. So here these are claims 1 through 6 and 23 of
8 the original application, that is, the original '141 patent
9 application, as it was filed on September 9th, 2008.

10 Q. So what would a person of ordinary skill in the
11 art conclude from the fact that these were the original
12 filed claims in the application filed in September 2008?

13 A. A person of ordinary skill would understand that
14 this is what the inventors believed they had invented.

15 Q. Were you present for opening statements by
16 Respondents' counsel?

17 A. Yes.

18 Q. And do you recall Respondents' counsel talking
19 about the prosecution history of one of the related
20 applications of the '141 patent?

21 A. I was.

22 Q. If we could bring up RDX-1 at slide 10, please.

23 Do you recall Respondents' counsel talking about
24 this particular slide?

25 A. Yes, I do.

1 Q. What was the inference they were making with this
2 particular argument?

3 A. Well, this is talking about a related
4 application, the '372 application, and the implication here
5 is that, after this was filed, that there were a series of
6 rejections that ultimately led in 2012 to a Notice of
7 Abandonment, and the first Office Action, the first
8 rejection, was in August 16, 2010.

9 Q. And this was in the '372 application?

10 A. That's correct.

11 Q. So the first Office Action was in August of 2010,
12 and how does that correspond to the date that the inventors
13 filed their original claims for the '141 patent?

14 A. The original claims had already been filed, I
15 think in September 2008, if memory serves.

16 Q. So if someone were to suggest that the '141
17 patent claims are a result of Office Action rejections or
18 delayed application, could that possibly be true?

19 A. No, sir, the timing just doesn't work.

20 Q. If we could go back to CDX-2 and slide 20,
21 please. Thank you.

22 So continue on with the asserted claims, doctor.

23 Is there written description support in the '141
24 patent for claim 2?

25 A. Yes, there is. So claim 2 narrows the FRAP

1 factor range to a FRAP factor of less than 200. And in the
2 '141 patent at column 6, lines 51-52, the patent states that
3 in another embodiment, the filter achieves a FRAP factor of
4 less than about 200.

5 Q. Now turning to claims 3 and 4, what do claims 3
6 and 4 require?

7 A. So claims 3 and 4 require that the volume of the
8 filter media be less than about 300 cc's or less than about
9 150 cc's.

10 Q. And is there written description support in the
11 specification of the '141 patent for those limitations?

12 A. Yes, in the specification at column 25, lines
13 37-40, the '141 patent states, in preferred embodiments, the
14 volume of the filter media (V) is less than about 300 cubic
15 centimeters, and so that is claim 3, and more preferably
16 less than about 150 cubic centimeters, which is the value
17 that appears in claim 4.

18 Q. If we could turn to slide 21 in CDX-2.

19 Doctor, with respect to claims 5 and 6 of the
20 '141 patent, what is required for those claims?

21 A. So these claims are directed to limitations on
22 the average filtration unit time (f), and claim 5 says that
23 that is less than about 12 minutes per liter, whereas claim
24 6 restricts it to less than about 6 minutes per liter.

25 Q. And is there support in the specification in the

1 '141 patent for those limitations?

2 A. Yes, at column 25, lines 42-45, it says that in
3 preferred embodiments, the average filtration unit time (f)
4 is less than about 12 minutes per liter, which is the same
5 value as in claim 5, and more preferably less than about 6
6 minutes per liter, which is the value that's in claim 6.

7 Q. If we could go to slide 22 in CDX-2.

8 Doctor, what does claim 23 require?

9 A. So claim 23 is directed towards a system for
10 filtering water. We often think of this in terms of the
11 water pitcher that appears in Fig. 1 in the '141 patent and
12 others, but this pitcher has a container having a source
13 water reservoir and a filtered water reservoir, and these
14 chambers are interconnected or in communication via a
15 cartridge through which water can flow, and that cartridge
16 has a filter in it that is the filter given in claim 1.

17 Q. So, in summary, doctor, we've gone through all
18 the asserted claims, is there literal written description
19 support for every limitation of the asserted claims in the
20 '141 patent specification?

21 A. Yes, for claims 1 through 6, and then here for
22 claim 23 we see that disclosure at column 12, lines 41-52.

23 Q. Now we heard testimony from Dr. Hatch that he
24 doesn't believe the inventors, correct?

25 A. I don't know if it's -- I don't know exactly what

1 he believes on that front.

2 Q. All right. So let's talk about a few things that
3 Dr. Hatch testified to. You heard Dr. Hatch testify that he
4 believes that the inventors did not have -- did not
5 demonstrate possession of any kind of filter media other
6 than carbon blocks.

7 Do you recall that?

8 A. Yes.

9 Q. What is your response to that?

10 A. I think that's -- that's not correct, and there's
11 numerous places in the patent, including in the claims, that
12 suggest otherwise.

13 Q. Let's bring up slide 25.

14 Can you describe some of the places where the
15 '141 patent discusses filter media besides carbon blocks?

16 A. So, for example, at column 13, lines 30-34, they
17 note that while the discussion will tend to focus on block
18 filters, it should be understood that the various materials
19 may be used in granular or loose media filter types
20 according to various embodiments of the present invention.

21 They also disclose further down at column 25,
22 lines 5-12, that the nature of the filter meeting the
23 following performance criteria is independent of the exact
24 embodiment of the filter and thus applicable to mixed media,
25 carbon blocks, nonwoven, hollow fibers and other filtration

1 formats.

2 And a bit further along at column 26, lines
3 30-37, they note that other embodiments of the present
4 invention include alternate filtration techniques such as
5 membranes, nonwovens, depth media, nanoparticles and
6 nanofibers, ligand, et cetera.

7 Q. Why, doctor, in your opinion, doctor, would a
8 person of skill in the art need to see a working embodiment
9 of a gravity-fed filter that used a nonwoven filter media to
10 understand that the inventors had possession of claim 1 of
11 the '141 patent?

12 A. I don't think a person of skill in the art in
13 this area would need that sort of working example to
14 understand that.

15 Q. And why is that?

16 A. Because there was -- there was so much
17 information available, not only in the patent, but also in
18 the art in this really well-studied field that would allow a
19 person of skill in the art to take the teachings on carbon
20 blocks in the '141 patent and apply those to other filter
21 media.

22 So, for example, the '141 patent requires that
23 the filter, whatever format it has, has activated carbon and
24 a lead scavenger. The activated carbon and lead scavengers
25 don't know or care what filter format they're in. They

1 perform their function independent of how they're organized
2 and what their geometry is.

3 And so a person of skill in the art could take
4 the teachings about activated carbon and lead sorbent
5 components that are useful in the '141 patent for carbon
6 blocks and could use those same components in other filter
7 media, and then without too much trouble experimentally
8 could make filters and test them, and I believe be
9 successful.

10 Q. Does the '141 patent describe common structural
11 chemical design features for activated carbons and lead
12 scavengers that a person of skill in the art would
13 recognize?

14 A. Yes, it does. And I think I have a slide on
15 that.

16 Q. Slide 23, please.

17 What are the common structural, chemical, or
18 design features described in the '141 patent that a skilled
19 artisan would understand to be applicable to other
20 applications, activated carbon and lead scavenger?

21 A. The structure in the claims of the '141 patent,
22 they always require activated carbon, they always require
23 lead scavenger, at least those two components. They always
24 are requiring that these components be organized into a
25 volume for filtration.

1 And so there are restrictions on the structures
2 that can be used to meet claim 1.

3 Q. And how would a person of skill in the art
4 understand the performance metrics in claim 1 to be
5 applicable to other filter media formats?

6 A. So they would understand that these performance
7 metrics are the lifetime of the filter, the filtration rate
8 and the effluent lead concentration rate at the end of
9 lifetime combining with the volume to give a FRAP factor of
10 less than 350, that those performance factors would be
11 impacted by the structure -- structural elements that we
12 just talked about, and then could be deployed in an
13 alternate format or alternate geometry to obtain good
14 performance.

15 Q. If we could go to slide 24, please.

16 With respect to claim 1 of the '141 patent,
17 doctor, would a person of skill in the art understand claim
18 1 to cover a filter with a volume of 0?

19 A. No, sir, I don't believe a person of skill in the
20 art would believe that.

21 Q. Why not?

22 A. Well, if it's -- if it's going to be a filter
23 that will actually filter water and remove lead, it has to
24 have some volume. Claim 1 says that the filter has a filter
25 media that includes at least activated carbon and a lead

1 scavenger. And so if you have any activated carbon and lead
2 scavenger in this filter, those components will have a mass,
3 and they will have a volume.

4 And so you can't have a volume of 0 and have a
5 filter that has at least activated carbon and lead scavenger
6 in it. A person of skill in the art would know that.

7 Q. Would a person of skill in the art understand
8 that a gravity-fed water filter could not have an average
9 filtration unit time with the lifetime of 0?

10 A. Yes, I believe so.

11 Q. Why is that?

12 A. Well, if you think about what it would mean to
13 have an average filtration unit time over lifetime L of 0
14 minutes per liter, that means that the water was being
15 filtered infinitely quickly through the filter. So that
16 isn't possible. And a person of ordinary skill in the art
17 would recognize that.

18 Moreover, a person of skill in the art, if
19 they're trying to meet all of the elements of claim 1, would
20 understand that the water has to have some contact time with
21 the filter media in order for the filter media to do its
22 job. And so that flow rate has to be in a range where there
23 would be sufficient contact time of the filter media with
24 the activated carbon and the lead sorbent so that it could
25 do its job at the very least of removing lead.

1 Q. Would a person of skill in the art understand
2 claim 1 to cover a filter with a lifetime of 0?

3 A. No, I don't -- I don't believe so. That would --
4 a filter with a lifetime of 0 would not be a filter, and so
5 it couldn't -- because it wouldn't be doing any filtering.
6 And also, if you set L, the lifetime, equal to 0 in the
7 denominator of this formula, the FRAP factor goes to
8 infinity. And so it would be above 350 in any case.

9 Q. And lastly, what about effluent lead
10 concentration at end of lifetime, could that be 0?

11 A. I don't believe it could be exactly 0. It could
12 be very low. It could be even below detection limit for
13 lead, and so it could be -- one could mistake it for 0, just
14 based on the ability of the equipment to detect lead, but I
15 think in any -- in any real filter, there will be some
16 effluent lead concentration. It may be very small, but
17 there will be some effluent lead concentration. There won't
18 be exactly 0.

19 Q. Dr. Freeman, did you hear the testimony from
20 Dr. Hatch where he pointed to the inventors' discussion of
21 certain prior art filters in their specification?

22 A. Yes, I did.

23 Q. If we could turn to slide 25.

24 I think we have already seen this slide once
25 before, but how would a person of skill in the art

1 understand the inventors' discussion of the prior filters in
2 the context of their invention?

3 A. They would understand that there were many types
4 of prior art filters and many different formats, and I think
5 what they're discussing here on these -- in these various
6 parts of the specification is the idea that the invention
7 that they're presenting in the '141 patent can be translated
8 to these other types of -- other types of filter media.

9 Q. And the fact that prior art filters were unable
10 to achieve a FRAP factor of 350 or less, how would that
11 disclosure -- how would a person of skill in the art
12 understand that specific disclosure in the '141 patent?

13 A. So I think what that disclosure would do is it
14 says, okay, the prior art filters of various types and
15 various formats were not able to achieve the properties and
16 the performance of the filters described in the '141 patent,
17 and what that would mean is that a person of ordinary skill
18 in the art would not abandon all of those prior art filters
19 and filter media types, but they would instead take the
20 teachings from the '141 patent and apply it to those prior
21 art filters.

22 So this provides a new road or a new mechanism
23 for increasing the performance of many types of filters for
24 water filtration.

25 Q. Doctor, let's turn now to your opinions

1 concerning enablement. If we can bring up slide 6.

2 Doctor, if you could just summarize, what are
3 your opinions with respect to -- as to whether the claims of
4 the '141 patent are enabled?

5 A. In my opinion the '141 patent does not lack
6 enablement.

7 Q. If we could go to the next slide, in forming your
8 opinions on whether the claims of the '141 patent lack or do
9 not lack enablement, what did you consider?

10 A. For enablement, I considered what are known as
11 the Wands factors. There are eight of them listed here, and
12 those together inform my opinion that the '141 patent
13 enables a person of skill in the art to make and use the
14 invention without undue experimentation.

15 Q. Doctor, why don't we start with the first three
16 factors there, the nature of the invention, predictability
17 of the art, and state of the prior art we have already
18 talked quite a bit about.

19 How do those factors inform your opinion as to
20 the enablement of the certain claims?

21 A. So the nature of the invention is gravity-fed
22 water filters, and we've heard several times today that this
23 is a well-known field and has been known for many decades if
24 not longer.

25 As a result of that, there's been a lot of study,

1 and there's a lot of information available about how to make
2 such filters, what are the components that go into them, how
3 do they perform, the basic theory underpinning them so that
4 they can be modeled.

5 And so the art in that sense is rather
6 predictable.

7 Additionally, the state of the prior art, as
8 we've discussed, is very significant. There's a lot of --
9 there's a lot of these sorts of filters available. There's
10 a lot of literature, handbooks, patent literature that is
11 available to help inform a person of skill in the art how to
12 make and use the invention.

13 Q. Let's talk next about the fourth Wands factor,
14 relative skill of an artisan.

15 How does that inform your opinion concerning
16 enablement of the asserted claims?

17 A. So a skilled artisan would have the skills to
18 make and test filters that are described in the '141 patent.

19 Q. In terms of the level of guidance in the '141
20 patent and working examples, how does that inform your
21 opinion?

22 A. So the working examples provide specific examples
23 of specific formulations where the inventors have been able
24 to meet the limitations of their claims, and they also give
25 additional guidance throughout the specification that

1 provides information to a person of skill in the art about
2 how to -- how to extend and expand on the working examples
3 to other media and to other examples with different
4 characteristics and different materials.

5 Q. Let me pause there, doctor. So all the working
6 examples are carbon blocks. We've heard that. Everyone
7 knows that.

8 How would a person of skill in the art take a
9 working example of a carbon block that is showing superior
10 lead reduction performance and good flow rates and good
11 lifetime, and take that as an example and then use that to
12 make, say, a nonwoven gravity-fed water filter?

13 A. So a person of skill in the art would know the
14 volume of that filter, would know the components that had
15 gone into it, the lead scavenger, the activated carbon, how
16 closely compressed the activated carbon and lead scavenger
17 had been with their -- with the binder, and that would give
18 an idea of the pore size that was available for filtration.

19 And a person of skill in the art could use those
20 same starting materials and apply them to a different
21 geometry, and could expect after -- after some
22 experimentation, but not undue experimentation, that they
23 would get a comparable performance to what you get in a
24 carbon block, because the components and the raw materials
25 that go into the filter are going to perform their function

1 in any filter media that they're put into.

2 MR. SWAIN: Your Honor, we, as Respondents, we
3 object to that following answer from Dr. Freeman as going
4 well outside of his expert report. We intend to file a
5 motion to strike by tomorrow per your ground rules on that
6 front.

7 JUDGE MCNAMARA: Thank you very much. I
8 appreciate that.

9 MR. SWAIN: Thank you.

10 Q. Doctor, you mentioned the pore size in your last
11 response there.

12 Can you just explain what you mean by pore size?

13 A. So when the carbon, activated carbon particles,
14 and if the lead scavenger is present as a particulate matter
15 as well, when you pack those together, the resulting
16 material is not perfectly solid with no pores or
17 interstitial regions in it. There will always be pores
18 between the particles at places where they don't pack
19 perfectly.

20 And it's in these interstitial regions or
21 pores -- this is where the water flows. And when the pore
22 size is small enough that it can block the particulate lead
23 that's of interest here, that's the mechanism for removing
24 particulate lead.

25 Additionally, the pore size controls or has a

1 strong influence on the flow of water through this region,
2 and this will then set the contact time that is useful
3 for -- for the lead scavenger to work, to remove the soluble
4 lead.

5 MR. SWAIN: Your Honor, we, Respondents,
6 respectfully object to that answer going well outside of
7 anything in Dr. Freeman's report or his deposition. We will
8 be filing a motion to strike on that as well.

9 JUDGE MCNAMARA: Thank you.

10 MR. SWAIN: Thank you.

11 Q. Dr. Freeman, this concept of pore size, is that
12 applied to different filter media formats?

13 A. Yes, absolutely.

14 Q. How so?

15 A. That in virtually all of the filter media formats
16 that you see in the handbooks that we've discussed and so
17 forth, you'll see discussions of the pore sizes of the
18 material that's used to do the filtration in those media,
19 and there's -- we looked earlier in the handbook of nonwoven
20 materials, there's a chapter on the theory of how fluids
21 like water flow through porous media, so there's a lot of
22 information about that.

23 Q. Now going to the next Wands factor, quantity of
24 experimentation, and I think you touched on this a little
25 bit in one of your answers, can you explain in your opinion

1 the degree of experimentation required for a person of
2 ordinary skill in the art to take examples and disclosure in
3 the '141 patent and to make a, say, a mixed-media filter
4 that met a FRAP factor of below 350?

5 A. So I think it's important to realize that in this
6 field it is routine to test filters to determine their
7 performance. And so a person of skill in the art, if they
8 had a head start from the '141 patent and the information
9 about the carbon block, could then use that knowledge and
10 the materials to make a mixed-media filter and achieve a
11 FRAP factor of less than 350 in relatively short time.

12 Q. And then lastly, I think we heard a lot from
13 Dr. Hatch earlier today on the breadth of the claims, how do
14 you believe breadth of claims factor weighs in terms of
15 enablement of the patent claims?

16 A. The claims are narrowed in the sense that they
17 require activated carbon and lead scavenger, so that narrows
18 them. They are also narrowed because they require this FRAP
19 factor value of less than 350 between the -- and that's
20 calculated from the volume of the filtration media, the
21 filtration flow rate, effluent lead concentration at the end
22 of lifetime, and the lifetime itself.

23 And those -- those grouping of variables are
24 interrelated with one another in a way that further
25 constrains the boundaries over which claim 1 applies, and I

1 think that favors enablement.

2 Q. Now in terms of the variables that go into the
3 FRAP factor, we have average filtration rate unit over time,
4 volume, lifetime, and reduction, the C_e value.

5 Would a person of skill in the art have the
6 knowledge, ability, and skill to modify each of those
7 factors individually and together?

8 A. A person of skill in the art would understand how
9 the materials, like the activated carbon, its nature, size
10 and structure and so forth, and the lead scavenger and its
11 characteristics, how those influence those variables and
12 also how the amount of them and the shape and the way
13 they're laid out, the format they're laid out in, how those
14 influence the variables appearing in the FRAP equation, and
15 they would be able to use that knowledge to put together a
16 mixed-media filter that would meet the performance in claim
17 1.

18 JUDGE MCNAMARA: Pardon me. Mr. Ainsworth, could
19 we take a break here? Can we take -- shall we take five
20 minutes?

21 MR. AINSWORTH: Absolutely, Your Honor. I have
22 one more question to finish this section.

23 JUDGE MCNAMARA: Sure. Sure.

24 MR. AINSWORTH: Thank you.

25 Q. Dr. Freeman, in conclusion, what is your opinion

1 with respect to whether claims 1 through 6 and 23 are
2 enabled by the specification of the '141 patent?

3 A. It's my opinion that they are enabled.

4 Q. Thank you.

5 JUDGE MCNAMARA: Thank you. I'll see you in five
6 minutes.

7 (Whereupon, the proceedings recessed at 2:38
8 p.m.)

9 (In session at 2:43 p.m.)

10 JUDGE MCNAMARA: All right. Good afternoon,
11 everyone. Mr. Ainsworth, I think you still have the floor.

12 MR. AINSWORTH: Yes. Thank you, Your Honor.

13 Q. Welcome back, Dr. Freeman.

14 Your Honor, my hot seat is not quite back yet.

15 JUDGE MCNAMARA: Okay. Technology, isn't it just
16 wonderful?

17 MR. AINSWORTH: It is, Your Honor. We rely upon
18 the team. Sometimes the team is a little late getting
19 back --

20 JUDGE MCNAMARA: I understand. I had some
21 problems myself today that I was not expecting.

22 MR. AINSWORTH: I think we're ready, Your Honor.

23 JUDGE MCNAMARA: Okay.

24 BY MR. AINSWORTH:

25 Q. Mr. Rennick, if you could please bring back up

1 the demonstrative, CDX-2, at slide 28.

2 Dr. Freeman, would you briefly summarize again
3 what your opinions are as to whether the '141 patent claims
4 meet requirements under section 101?

5 A. So I believe they do, because the asserted claims
6 are directed towards an article of manufacture and prior art
7 filters and the '141 does not unduly preempt commercial
8 gravity-fed water filters.

9 Q. Next slide, Mr. Rennick.

10 And we're looking here at claim 1. Could you
11 explain why in your opinion the claims of the '141 patent
12 are not directed to an abstract idea?

13 A. Well, so claim 1 starts out by calling out a
14 gravity-fed water filter, and so that's a physical device,
15 something that can be manufactured. An example of a drawing
16 of it is shown in Fig. 5. It states that it has a filter
17 media having activated carbon and a lead scavenger, so those
18 are known materials that can be procured and put into such a
19 filter.

20 And then it gives the FRAP factor, which is the
21 performance of the filter.

22 So this claim is directed to a device and to a
23 device that can be manufactured.

24 Q. How do you respond to the criticism that the
25 claims of the '141 patent are simply drawn to a result or an

1 ability?

2 A. I think that's not right. They're drawn to a
3 physical article, a manufacture, that has specific
4 performance characteristics. There are working examples
5 that demonstrate the making of these -- of these devices.
6 And so I don't think it's directed at just an idea.

7 Q. You mentioned the activated carbon, the lead
8 scavenger.

9 What about the FRAP limitation in claim 1 denotes
10 structure to a person of ordinary skill in the art?

11 A. So the FRAP limitation really provides a
12 compilation of key design and performance criteria that work
13 together to give that FRAP value. So the volume of the
14 filter media, and the filter media we've just discussed what
15 it has to have in it, the filter media and the shape of the
16 article ultimately determines the flow rate, the lifetime
17 and the effluent lead concentration are intimately linked to
18 one another. And so all of these variables provide
19 structure to this device.

20 Q. What about the effluent lead concentration at end
21 of lifetime, how does that performance property relate to
22 structure of a gravity-fed water filter?

23 A. So the effluent lead concentration at the end of
24 the lifetime is going to depend upon the nature of the
25 components, the activated carbon and the lead scavenger, the

1 amount of those components, their layout, the format size
2 and shape of the filter. And it will also depend on the
3 packing of those particles in the sense that that impacts
4 the filtration unit time and, therefore, the contact time of
5 the water with the components of the filter.

6 Q. If we can turn to slide 30, Mr. Rennick.

7 What in claim 23 of the '141 patent in your
8 opinion relates to the structure of the claimed invention?

9 A. So claim 23 is directed towards a device or
10 gravity-flow system that has specific properties. We're
11 told it has to have a source water and a filtered water
12 reservoir, and there has to be a cartridge that allows those
13 two reservoirs to communicate. And that cartridge has to
14 have a filter in it that can filter the water from one
15 reservoir to another. So those are all definite physical
16 structures that can be put together and assembled and made.

17 Q. Doctor, you were here when Dr. Knipmeyer
18 testified on the first day of the evidentiary hearing?

19 A. I was.

20 Q. Do you recall what she had said about what the
21 problem was she was trying to solve and how they solved it?

22 A. So Dr. Knipmeyer, to paraphrase, said that there
23 was a new -- a new standard coming from NSF related to lead
24 reduction, and that the current generation filters couldn't
25 meet that lead standard.

1 And so what they were working on, what they
2 invented, were filters that met the new lead standard and
3 also had good flow rate and ultimately had volumes that were
4 compatible with some of their existing products. And so
5 that was what they invented.

6 Q. And in your opinion is that solution reflected in
7 the asserted claims of the '141 patent?

8 A. It is.

9 Q. How are the claimed filters of the '141 patent
10 been proven over what existed before?

11 A. So in the prior art there were certainly filters
12 that could filter -- that could filter water, but they
13 couldn't achieve the lead reduction that was going to be
14 coming under this new standard and while also maintaining --
15 maintaining good fast flow.

16 Q. Have you heard the criticism that the '141 patent
17 claims unduly preempt gravity-fed water filters?

18 A. I have.

19 Q. Do you agree with that?

20 A. No, I don't think that's -- I don't think that's
21 true.

22 Q. And why is that?

23 A. Because it would be possible to design a filter
24 that did not rely on the invention in the '141 patent and
25 still meet those NSF standards.

1 So, for example, one could make a filter with a
2 larger volume and a filter with a slow flow rate, and those
3 filters could fall outside the FRAP range but still satisfy
4 the NSF standard on effluent lead concentration. One could
5 also, if you look even broader, beyond just gravity-fed
6 water filters, one could make pressurized water filters, and
7 those wouldn't be a part of this either.

8 Q. Thank you, doctor.

9 If we could please bring up CDX-2 at slide 31,
10 please.

11 Doctor, now let's turn to your opinions
12 pertaining to conception, reduction to practice, and
13 priority for the '141 patent claims.

14 If we could just turn to the next slide,
15 Mr. Rennick.

16 What is shown on slide 32, Dr. Freeman?

17 A. So this is some key events that led up to the
18 filing of the '141 patent. Starting in May, May 16th, 2006,
19 is when I've identified as the conception of the invention.

20 Shortly after that, over a few months, in July
21 and August, the first actual reductions to practice were
22 realized.

23 In September of 2006 then Elizabeth Knipmeyer had
24 circulated an internal memorandum that was articulated in
25 the FRAP and the FRAP calculations. The new standards came

1 a few months later, in early 2007.

2 After that, in late 2007, October 2007, the '372
3 application was filed, and ultimately in September 2008 the
4 '141 patent application was filed.

5 Q. So let's start with the May 16th, 2006 date. Why
6 is it your opinion that the inventors first conceived of
7 their invention by that date?

8 A. So I've seen testimony and documents that support
9 that point of view, such as the one that's referred to here
10 in this timeline.

11 Q. If we could bring up Exhibit 932, Mr. Rennick,
12 please.

13 Do you recognize Exhibit 932?

14 A. I do.

15 Q. Was this one of the documents that Dr. Knipmeyer
16 testified to at the evidentiary hearing?

17 A. Yes, it was.

18 Q. And what would a person of ordinary skill in the
19 art understand from the information provided in CX-932?

20 A. So it has two columns of information. On the
21 left-hand side column is what are called characteristics and
22 on the right-hand side are parameters. And so the
23 characteristics are the performance that Dr. Knipmeyer and
24 her colleagues are seeking, and in the parameters column are
25 the variables that they understand can be manipulated to

1 influence that insoluble lead removal in this case.

2 Q. Now what does Exhibit 932 disclose about the
3 relationship between the filtration and flow rate?

4 A. So the flow rate is the second characteristic,
5 and it says that they want a parity flow rate. I believe
6 that's parity with their existing filters. And it says in
7 order that the -- what they understand to be able to
8 manipulate that are some characteristics, if it's a carbon
9 block, you can make the block thicker and if the block gets
10 thicker the flow rate goes down, of course, can increase the
11 density of the block, that is compress it, bring the
12 particles closer together, narrows the pore sizes, and that
13 makes the flow rate go down. You can change the block
14 surface area, if there's more surface area, there's higher
15 flow and block shape can also be used to vary the flow rate.

16 Q. What does Exhibit 932 disclose to a person of
17 skill in the art about what the inventors conceived of in
18 terms of types of filter media?

19 A. So you can see this in the top, in the top entry
20 under Parameters. And so they're talking about being able
21 to influence insoluble lead removal. And the first bit of
22 that is talking about what are the block characteristics, if
23 it's a carbon -- if it's a block-type filter, what are the
24 block characteristics that can influence insoluble lead
25 removal.

1 But then they go on and they talk further on down
2 in that entry about physical filters. And so these are
3 nonwoven and carbon sheets. So they're clearly thinking
4 about the use of filters other than carbon blocks to achieve
5 their goal.

6 Q. And what does Exhibit 932 indicate about the
7 inventors' identification of lead scavenger as an element of
8 their idea?

9 A. Yeah, so down at the third entry in the column is
10 soluble lead removal, and they talk about lead sorbents, the
11 type and quantity of lead sorbents, of course, can influence
12 that. The ion exchange resin, if one uses an ion exchange
13 resin, can affect soluble lead removal, and whether you have
14 that mixed in with the carbon or outside of the carbon block
15 can also have an effect on that.

16 Q. Now, doctor, does Exhibit 932 itself describe
17 what we all know to be the FRAP equation?

18 A. So Exhibit 932 does not have the FRAP equation
19 written into it explicitly.

20 Q. But what does Exhibit 932 say about the
21 relationship of those variables that make up the FRAP
22 equation?

23 A. So this exhibit is showing that the variables
24 that affect the characteristics that they want to influence,
25 like the insoluble and soluble lead removal and the parity

1 flow rate, that the variables that influence that are going
2 to be a block or filter media volume, the components that
3 go -- that go into it, and so they have a lead sorbent and
4 activated carbon.

5 You can see down towards the bottom that they
6 want parity with their existing filter life. And they
7 mention the NSF 53 health claims, and this is where you get
8 into things like removal of lead, so the effluent lead
9 concentration. So all of the elements important in the FRAP
10 equation are here in this document.

11 Q. And if we go to the first bullet point under the
12 table on Exhibit 932, it states, develop a relationship
13 between block thickness, density (carbon granule size,
14 binder, carbon ratio) insoluble lead removal and flow rate.

15 What does that indicate to a person of ordinary
16 skill in the art?

17 A. I think a person of ordinary skill would
18 understand that they're trying to develop a detailed and
19 perhaps predictive relationship between these variables.

20 Q. In summary, what, in your opinion, what does
21 Exhibit 932 show?

22 A. Exhibit 932 shows that the inventors understood
23 the characteristics of the filters that they were going to
24 make and how those impacted the properties and performance
25 of the filters. In other words, they understood what they

1 needed to do to and how they were going to go about doing it
2 to achieve the invented filters.

3 Q. So this was May --

4 You can take this down, Mr. Rennick.

5 This was May 2006. What is your understanding
6 from the testimony of Dr. Knipmeyer as to what they did
7 next?

8 A. My understanding is that they started making and
9 testing filters and then measuring the performance of those
10 filters and then comparing them to their goals, basically.

11 Q. And in forming your opinions in this case,
12 doctor, have you reviewed Dr. Knipmeyer's lab notebooks and
13 other research materials and records from that time period?

14 A. I have.

15 Q. And have you identified or formed an opinion as
16 to whether there were actual reductions to practice of the
17 claims of the '141 patent?

18 A. I believe there were.

19 Q. Could we go to slide -- go back to CDX-2, slide
20 33, please. Let's go to the next slide, please.

21 We're on now slide 34 of CDX-2. What are you
22 showing on this slide, doctor?

23 A. So this is an excerpt of a page from one of
24 Dr. Knipmeyer 's laboratory notebooks that was related to
25 her work in formulating and testing filters.

1 Q. And what is the date on which this particular
2 information was recorded?

3 A. June 28, 2006, so it's a little over a month past
4 that document we just looked at.

5 Q. And what information is provided about the
6 formulations that were manufactured on June 28th, 2006?

7 A. So in the first column in the top table it lists
8 under Formulation, HMM 80 x 325. This is a form of
9 activated carbon. And under it, it has the Alusil 40-70,
10 which is a lead scavenger. This table gives the amount or
11 the weight percent of those components. The third component
12 there is a binder to hold the activated carbon and lead
13 scavenger together in the desired shape.

14 Q. And the sample number you're focused on here is
15 PA-2?

16 A. Yes, that's correct.

17 Q. What do we know about the shape of PA-2-2?

18 A. This was their so-called Maxtra filter or I think
19 they also called it bathtub-shaped filter.

20 Q. Next slide, please. Now we're on slide 35 of
21 CDX-2.

22 What is shown on this page, Dr. Freeman?

23 A. So what's shown here is a sketch by Dr. Knipmeyer
24 of the shape of the filter on the left, and on the right she
25 is going about and calculating the volume of that filter,

1 and it comes out to 105 cubic centimeters.

2 Q. And, ultimately, did Dr. Knipmeyer test filter PA
3 2-2?

4 A. She did.

5 Q. Next slide. First of all, how did she test the
6 filter?

7 A. So, basically, she made a challenge water
8 according to the protocols that were being suggested by NSF,
9 and so that gives a soluble and insoluble lead in it. And
10 then she filtered that challenge water through the filter
11 and measured at the flow rate after each liter of water
12 filtered and at certain points measured the effluent lead
13 concentration in parts per billion.

14 And she did that -- she was looking for a
15 lifetime of the filter, what they wanted was that the filter
16 would have a 40-gallon lifetime, and by NSF, the NSF
17 standards, you would test out to 200 percent of the
18 lifetime, which would be 80 gallons or 303 liters. And so
19 she's carried out that test here.

20 Q. And the results that you show on slide 36, that's
21 from CX-108C, page 129; is that right?

22 A. Yes, and page 81 as well for the filter life.

23 Q. And those are pages from Dr. Knipmeyer's notebook
24 that we heard testimony from her on earlier in the hearing?

25 A. That's correct.

1 Q. And on what date did Dr. Knipmeyer sign the page
2 where these experiments were shown?

3 A. August 16th, 2006.

4 Q. And for the effluent concentration shown for PA
5 2-2, what does that show in terms of the lead performance of
6 that filter in that test?

7 A. So the effluent concentrations here are the lead
8 concentration in parts per billion, and it shows that, after
9 151 liters, which would correspond to 40 gallons, the
10 effluent lead concentration is 2.05 parts per billion, and
11 at the end of twice the lifetime or 303 liters it's 8.45
12 parts per billion. So both those are less than the 10 part
13 per billion target that they were aiming for.

14 Q. If we can go to the next slide.
15 What is shown on this slide, doctor?

16 A. So here on slide 2.37 I'm showing the flow rate
17 data that Dr. Knipmeyer collected for this filter. And so
18 she measured the flow rate as each liter of water was
19 filtered through the filter.

20 So, for example, after the first liter of water
21 had been filtered, it took 10 minutes and 45 seconds, and
22 she continued to do this all the way down until she reached
23 the desired filter lifetime of 151 liters, and then averaged
24 those filtration times to come up with a value of 8.5
25 minutes per liter on average to filter the challenge water

1 through the filter.

2 Q. Did you calculate the FRAP factor for this
3 embodiment?

4 A. Yes, I did.

5 Q. What is that?

6 A. So using a volume that Dr. Knipmeyer calculated,
7 105 cubic centimeters, the average filtration rate of 8.5
8 minutes per liter, the effluent lead concentration at the
9 end of the lifetime, 2.05 parts per billion, and dividing
10 that by twice the filter lifetime of 40 gallons, you get a
11 FRAP factor of 22.9.

12 Q. And is the PA 2-2 filter also disclosed in the
13 '372 application?

14 A. It is.

15 Q. If we can go to the next slide.

16 What is shown on this slide, doctor?

17 A. So on slide 2.38 is shown another reduction to
18 practice. This one is called PA 3-8.

19 Q. And what is the manufacture date of PA 3-8?

20 A. July 25, 2006.

21 Q. And what were the components of that filter?

22 A. It had HMM 80 x 325, so that's a trade name for
23 activated carbon, and it had Alusil 40-70, which is a lead
24 scavenger, and it also had a binder.

25 Q. And if we go to the next slide, what was the

1 shape -- on slide 39 of CDX-2 -- what was the shape of the
2 PA 3.8 filter?

3 A. This was what they called the pantaloon-shape
4 filter, and a drawing of that is shown on the left-hand side
5 of the slide, and from that the volume can be calculated.
6 It's 5.41 cubic inches and that equates to 89 cubic
7 centimeters.

8 Q. Is the PA 3-8 disclosed as an embodiment, a
9 working embodiment in the '141 patent?

10 A. It is.

11 Q. If we go to the next slide, what is shown on
12 slide 40?

13 A. On slide 40 is shown the desired filter lifetime
14 40 gallons, in the upper left-hand corner, the table on the
15 right, again, it shows the effluent lead concentration
16 measured at several points during the filtration. And it
17 shows that the end of lifetime the effluent lead
18 concentration is 7.45 parts per billion, which is less than
19 the 10 parts per billion they were targeting, and that at
20 the end of twice the lifetime the lead concentration was
21 8.47 parts per billion.

22 Q. What did Dr. Knipmeyer conclude in her notebook
23 page -- from page 122 of CX-108 -- what does she conclude at
24 the time she recorded her results?

25 A. So what she concluded was that all blocks

1 exhibited fast and consistent flow rates, lead removal was
2 consistent across the test with passing results for PA 3-8.

3 Q. And what date did she record that?

4 A. August 16, 2006.

5 Q. And if we go to the next slide, we're now on
6 slide 41, what is shown here, doctor?

7 A. Similar to the previous example, this is the
8 measurement of the flow rate liter by liter. She averaged
9 it, as she did before, to get an average filtration time of
10 4.4 minutes per liter, and then from that then the other
11 information you can calculate a FRAP factor.

12 Q. And what was the FRAP factor for PA 3-8?

13 A. 36.5.

14 Q. In summary, doctor, what is your opinion as to
15 whether the PA 3-8 was an actual reduction to practice of
16 claim 1 of the '141 patent?

17 A. In my opinion it was.

18 Q. Are you aware of any dispute over that?

19 A. No, I'm not.

20 Q. And what is your opinion as to whether it's an
21 actual reduction to practice of claims 2 through 6?

22 A. In my opinion it is.

23 Q. And are you aware of any dispute over that?

24 A. No.

25 Q. And I don't think I asked you those questions

1 about the earlier filters. Let me just do that as well.

2 For filter PA 2-2, what is your opinion as to
3 whether it is a reduction to practice of the subject matter
4 of claim 1?

5 A. In my opinion it is.

6 Q. Are you aware of any dispute on that?

7 A. No, I'm not.

8 Q. And is it a reduction to practice of claim 2 as
9 well?

10 A. Yes, that's correct.

11 Q. And is it an actual reduction to practice of
12 claims 3 and 4?

13 A. Yes.

14 Q. And is it an actual reduction to practice in
15 claim 5?

16 A. Yes.

17 Q. And with respect to dependent claims, are you
18 aware of any dispute that PA 2-2 is an actual reduction to
19 practice those claims?

20 A. No, I'm not.

21 Q. Thank you, doctor.

22 Now let's turn to the last topic for today,
23 priority to the '372 application.

24 If we could bring back up the demonstratives to
25 slide 43.

1 First of all, what is your understanding of the
2 relationship between the '372 application and the '141
3 patent?

4 A. It's my understanding that the '372 application
5 appears on the face of the '141 patent that's shown here on
6 the information on the front of the '141 patent.

7 Q. Have you formed an opinion as to whether the
8 asserted claims of the '141 patent are entitled to claim
9 priority to the benefit of the filing date for the '372
10 application?

11 A. I believe they are.

12 Q. And are you aware of whether the United States
13 PTAB has reviewed the claims of the '141 patent and
14 determined that they are entitled to priority to the '372
15 application?

16 A. They did, and they have determined that the '141
17 patent can claim priority to the '372 application.

18 Q. We'll come back to that in a couple minutes,
19 doctor.

20 Let's look at the '372 application. What is your
21 understanding -- let me back up.

22 What is your understanding of what's required to
23 be shown to allow the inventors to claim priority back to an
24 earlier application?

25 A. It's my -- it's my understanding that that

1 earlier application has to provide enablement in the written
2 description of the claims that are claiming priority to it.

3 Q. And have you formed an opinion as to whether the
4 '372 application provides such written description and
5 enabling disclosure for the claims?

6 A. I believe that it does.

7 Q. Mr. Rennick, could we bring up slide 44, please.

8 Starting with the first element of claim 1, where
9 does the '372 application provide disclosure for element
10 1(p)?

11 A. So this is -- the claim element is a gravity-fed
12 water filter, and in the '372 application at paragraph 16 it
13 says it would be useful to have a gravity flow filter that
14 exhibits both good water flow rates and high contaminant
15 reduction.

16 Further on, at paragraph 118, it says that other
17 embodiments include filters for use in gravity flow or low
18 pressure application that meet a specific performance range
19 of operation, and it goes on from there.

20 Q. If we can go to slide 45.

21 With respect to element 1(a), what is your
22 opinion, doctor, as to whether there's support in the '372
23 application for element 1(a)?

24 A. So element 1(a) says that the filter media has to
25 include at least activated carbon and a lead scavenger, and

1 in the '372 application at paragraph 17 it talks about a
2 gravity-fed, in the Summary of the Invention, it talks about
3 a gravity-fed carbon block water filter according to one
4 embodiment of the present invention includes activated
5 carbon particles, a binder material interspersed with the
6 activated carbon particles, and a lead scavenger.

7 Q. Let's go to the next slide, Mr. Rennick.

8 Now does the '372 application disclose
9 gravity-fed filters with activated carbon, lead scavenger,
10 and that achieve a FRAP factor of less than about 350?

11 A. So the '372 application does not have the FRAP
12 factor explicitly written and disclosed in it, but I believe
13 that the filters with this performance are inherently
14 disclosed in the '372 application.

15 Q. If we go to slide 47 of demonstrative 2.

16 First of all, where do you find that disclosure
17 in the '372 application?

18 A. So the '372 application discloses a number of
19 working examples, and they also mention under the
20 performance section, at paragraph 118, that the other
21 embodiments include filters for use in gravity flow or
22 low-pressure applications that meet a specific performance
23 range of operation defined by filter volume, defined usage
24 lifetime, average time of filtration, and/or lead reduction
25 ability, and those are the four variables that appear in the

1 FRAP equation.

2 Q. While we're there on this section, what does the
3 '372 application also say about the types of filter media
4 that were contemplated in the '372 application?

5 A. So it says that the nature of the filter
6 "meeting," should be "medium," the nature of the filter
7 meeting, the following performance criteria is independent
8 of the exact embodiment of the filter and thus applicable to
9 mixed matrix, carbon blocks, nonwovens, hollow fibers, and
10 other filtration formats.

11 Q. In paragraph 119 here from the '372 application,
12 what does it describe about the performance of the filters
13 disclosed in that application?

14 A. It says at paragraph 119 that, as noted above, a
15 lead concentration in the final liter of effluent water
16 filtered by some embodiments of a block filter is less than
17 about 10 micrograms per liter after approximately 151 liters
18 (40 gallons) of source water filtration, and then it gives
19 the characteristics of the source water, and those same
20 characteristics follow through to the '141.

21 Q. If we could go to the next slide, please.

22 Doctor, what is shown on slide 48 of CDX-2?

23 A. So this shows Table XIII from the '372
24 applications, and it shows a number of cup-shaped filters
25 that they made and tested at the top of the table. And at

1 the bottom of the table are filters that are prior art
2 filters that were available on the market. And it shows for
3 each of those filters the lifetime L in gallons, the
4 filtration rate, f, in minutes per liter, the filtration
5 volume, V, in cubic centimeters, and the effluent lead
6 concentration in parts per billion.

7 Q. Now did the inventors calculate or include the
8 FRAP factor values in the '372 application for these
9 filters?

10 A. They did not explicitly include those values in
11 the '372 application.

12 Q. So over on the right-hand side --

13 MR. SWAIN: I apologize, Mr. Ainsworth.

14 If I may, Your Honor, I want to lodge an
15 objection to any testimony regarding embodiment PA, that's
16 papa alpha, 3-2, by Dr. Freeman here, and we'll put this in
17 a motion to strike, but that embodiment was discussed
18 nowhere in his report or his deposition, but we will take
19 that up on the papers.

20 JUDGE MCNAMARA: Okay. Thank you, Mr. Swain.

21 Q. Dr. Freeman, sorry, I believe I was asking you,
22 did you calculate the FRAP factors for embodiments described
23 in Table XIII?

24 A. Yes, I did.

25 Q. And were the FRAP factors for each of those

1 embodiments below 350 and below 200?

2 A. Yes, they were.

3 Q. And what was the range on FRAP factors for those
4 embodiments?

5 A. From about 20 to something over a hundred.

6 Q. Now you have a note here on your slide about
7 amendment to specification. Did you just want to explain
8 what that amendment was, doctor?

9 A. Sure. The volume of the filter media shown here
10 is 99.7 cubic centimeters. The volume in Dr. Knipmeyer's
11 notebook for these filters is 105 cubic centimeters. And
12 there was an amendment to the specification filed, and it
13 also included a volume of 105 cubic centimeters. And so I
14 used that value in calculating the FRAP values.

15 Q. And the columns that you talked about with L, f,
16 V, and Ce, are the definitions for those variables in the
17 '372 application the same definitions that were used in or
18 equivalent to the same definitions used in the '141 patent?

19 A. They are.

20 Q. Why don't we take a look at that. If we can go
21 to the next slide.

22 What does the '372 application say about volume
23 of filter media?

24 A. So at paragraph 174 of the '372 says the filter
25 volume (V) is defined as the volume of filtering a media,

1 and it goes further to say that, in preferred embodiments,
2 the volume of the filter media (V) is less than about 300
3 cubic centimeters and more preferably less than about 150
4 cubic centimeters.

5 Q. How does that correspond to the disclosure in the
6 '141 patent?

7 A. It matches up with the disclosure here in 1(b)
8 and also with some of the dependent claims.

9 Q. If we go to the next slide, please, Mr. Rennick.
10 What does the '372 application disclose with
11 respect to the average filtration time over lifetime?

12 A. In the '372 application at paragraph 124 it says
13 the average filtration unit time (f) is the time -- is
14 defined as the time it takes to filter one liter of water
15 averaged over all filtered liters in the defined filter
16 lifetime.

17 And in preferred embodiments, the average
18 filtration unit time (f) is less than about 12 minutes per
19 liter and more preferably less than about 6 minutes per
20 liter.

21 Q. And how does that correspond to the disclosure in
22 the '141 patent specification?

23 A. It's the same.

24 Q. If we can go to the next slide, Mr. Rennick,
25 slide 51, please.

1 Now with respect to the source water recited in
2 claim 1 of the '141 patent, what disclosure is there
3 corresponding to that in the '372 application?

4 A. So paragraph 119, it notes that the lead
5 concentration in the final liter of effluent water filtered
6 by some embodiments of a block filter is less than 10
7 micrograms per liter, and it gives the source water pH
8 concentrations and so forth that are consistent with what's
9 shown in the claims of the '141, and it says, at paragraph
10 120, preferably the source water is prepared as defined in
11 the NSF/ANSI 53 protocol (2007).

12 Q. And is source water prepared in accordance with
13 the NSF/ANSI 53 protocol, is that within the scope of the
14 source water recited in claim element 1(b) of the '141
15 patent?

16 A. Yes.

17 Q. If we could go to the next slide, Mr. Rennick.

18 And, lastly, for the lifetime variable from the
19 '141 patent, claim 1, where is the corresponding disclosure
20 in the '372 application?

21 A. On the '372 application, at paragraph 125, it
22 says the filter usage lifetime (L) in some embodiments may
23 be defined as the total number of gallons that can be
24 effectively filtered according to claims presented by the
25 manufacturer or seller of the filter.

1 Q. If we could go to the next slide.

2 So does the '372 application explicitly disclose
3 a FRAP factor of about 350 or less?

4 A. The '372 does not have explicit values of the
5 FRAP factor in it, but it does note at paragraph 118 that
6 the other embodiments, the filter for use in gravity flow or
7 low-pressure applications that meet a specific range of
8 operation defined by filter volume, defined usage lifetime,
9 average time of filtration, and/or lead reduction ability,
10 and so it is -- it is inherently disclosing that there's a
11 specific performance range of these variables, and that
12 gives you a specific range of FRAP values.

13 Q. So just in summary, doctor, what is your opinion
14 as to whether the '372 application discloses a gravity-fed
15 water filter with activated carbon, lead scavenger, and a
16 FRAP factor of less than about 350?

17 A. I believe that it does.

18 Q. If we could turn to slide 54.

19 In terms of claim 2, doctor, of the '141 patent,
20 does the '372 application provide disclosure of that
21 element?

22 A. Yes. Claim 2 is for FRAP factors of less than
23 200, and for the same reasons that I've set forth for claim
24 1, I believe that that disclosure is in the '372 patent.

25 Q. Is that inherent in the '372 application?

1 A. It is.

2 Q. Now with respect to claim 3 and claim 4, does the
3 '372 application provide support for those dependent claims?

4 A. Yes. So claims 3 and 4 restrict the volume in
5 the filter media to be less than about 300 cubic centimeters
6 or less than about 150 cubic centimeters, and in the '372
7 application, at paragraph 174, it says that in preferred
8 embodiments the volume of the filter media (V) is less than
9 about 300 cubic centimeters, which corresponds to claim 3,
10 and more preferably less than about 150 cubic centimeters,
11 which corresponds to claim 4.

12 Q. If we could go to the next slide, please.

13 What about claims 5 and 6, doctor? What is your
14 opinion as to whether the '372 application provides support
15 for those dependent claims?

16 A. So claims 5 and 6 add limitations on the average
17 filtration unit time (f) and that it should be less than
18 about 12 minutes per liter in claim 5 and less than about 6
19 minutes per liter in claim 6.

20 In the '372 application, at paragraph 124, it
21 says that in preferred embodiments the average filtration
22 time (f) is less than about 12 minutes per liter, which
23 would correspond to claim 5, and more preferably less than
24 about 6 minutes per liter, which would correspond to claim
25 6.

1 Q. If we could go to slide 56, please.

2 To close it out, on claim 23, what is your
3 opinion as to whether the '372 application provides support
4 for claim 23 of the '141 patent?

5 A. I believe that it does. This is the claim to the
6 system, and which has a source water and a filtered water
7 reservoir and a cartridge between them that holds a filter
8 from claim 1. And we see disclosure of that in several
9 places in the '372 application.

10 One is in Fig. 1 here, which shows the -- it
11 shows a container, a pitcher in this case, that has a source
12 water reservoir and has a filtered water reservoir, it has a
13 cartridge that's in communication between those two, and a
14 filter that is put inside that cartridge.

15 Q. Thank you, Dr. Freeman. Earlier you mentioned
16 that the Board had already reached a conclusion regarding
17 the priority of the '141 patent's claim to priority to the
18 '372 application.

19 If you could bring up slide 57, please?

20 Just to remind the Court, who was the petitioner
21 in that proceeding before the PTAB?

22 A. It was Kaz USA, which I understand is the PUR
23 Respondent.

24 Q. And what is your understanding of what was the
25 basis for the Board's decision that the '141 patent was

1 entitled to claim priority to the '372 application?

2 A. My understanding was that the petitioner, Kaz,
3 provided sworn testimony that the '372 application disclosed
4 all the limitations of the asserted claims of the '141
5 patent, and then that the PTAB relied on that information in
6 instituting their -- making their decision.

7 Q. And if we could bring up Exhibit CX-347.

8 Do you recognize CX-347?

9 A. Yes, I do.

10 Q. And what is that document?

11 A. So that's the petition by Kaz USA.

12 Q. Scroll down.

13 A. And there's the -- I'm sorry. This is the
14 decision by the PTAB.

15 JUDGE MCNAMARA: Pardon me, Mr. Ainsworth.
16 What's the date on that, please?

17 MR. AINSWORTH: Absolutely. If you go to the
18 top, paper 16 was dated March 31st, 2017, Your Honor.

19 JUDGE MCNAMARA: Thank you.

20 Q. You can take that down, Mr. Rennick, and bring
21 back the demonstratives, please. We're on slide 58 of
22 CDX-2.

23 With respect to the question of whether the '372
24 application provides an enabling disclosure for the claims,
25 the asserted claims, of the '141 patent, what is your

1 opinion?

2 A. It's my opinion that it does provide enabling
3 disclosures to enable a skilled artisan to make filters that
4 meet the limitations, the asserted claims of the '141
5 patent, without undue experimentation.

6 Q. And are many of the opinions you discussed with
7 respect to the enabling disclosure of the '141 patent
8 applicable here to the '372 application as to the state of
9 the art, et cetera?

10 A. Yes, that's correct.

11 Q. Could you just explain that, your analysis, of
12 why the '372 application provides enabling disclosure for
13 the '141 patent claims?

14 A. So the '372 application describes in a number of
15 places, including the working examples, how to adjust the
16 FRAP variables and ranges that would be of interest. They
17 teach that the invention in '372 would apply to different
18 types of filter media. They provide working examples, and
19 this would be a good place to start for a skilled artisan to
20 make filters within the scope of the asserted claims.

21 And I think, based upon the state of the art in
22 this field, it's important to understand that it's routine
23 to actually make and test filter prototypes to see the
24 specific values, their specific performance. And one can
25 also do that in -- according to the NSF 53 standard, and

1 that standard was incorporated by the '372 application.

2 And, finally, I think a contribution to the
3 enabling disclosure is that this gravity-fed water
4 filtration technology was a well-developed field, there was
5 a lot of prior art and information available to a skilled
6 artisan to assist them in this effort.

7 Q. Are you aware that Dr. Hatch has criticized the
8 disclosure of the '372 application for essentially the same
9 reasons that he criticized the disclosure of the '141
10 patent?

11 A. Yes, I believe that's correct.

12 Q. And is your response to those criticisms the
13 same?

14 A. Yes.

15 Q. So with respect to, for example, disclosure of
16 filter media and the types of filter media, would a person
17 of skill in the art -- strike that.

18 The fact that the '372 applications' working
19 embodiments are only showing carbon block filters change
20 your opinion as to whether the '372 application provides
21 enabling disclosure of the full scope of claim 1?

22 A. No, it doesn't.

23 Q. Why is that?

24 A. Because the '372 application also specifically
25 points out that the invention applies to other filter media,

1 and then it discusses a number of those filter media. It
2 also ties in with all the information that a person of skill
3 in the art would have in the field to access to help in
4 making that transition from one filter media to another.

5 Q. If we can go to the next slide.

6 I think we had this paragraph 118 up before on
7 slide 59, but just to remind and emphasize a point, what
8 does the '372 application say about its applicability to
9 other media?

10 A. So in paragraph 118, just after it's talking
11 about the filters that meet a specific performance range
12 that's defined by the variables that enter the FRAP
13 equation, it says the nature of the filter meeting the
14 following performance criteria is independent of the exact
15 embodiment of the filter and thus applicable to mixed-media,
16 carbon blocks, nonwovens, hollow fibers, and other
17 filtration formats.

18 Q. If we go to the last slide, slide 60,
19 Mr. Rennick.

20 Does the '372 application provide even further
21 detail about other media formats that are within the scope
22 of its disclosure?

23 A. Yes. So it talks about, at paragraph 95, filter
24 sheets, and it talks about those in the context of using
25 them with a porous composite carbon block, and it notes that

1 the filter sheet can enhance the performance and extend the
2 life of the block filter.

3 In the next paragraph at 96 it says that filter
4 sheet can include a woven or nonwoven sheet material, and it
5 goes on to describe further characteristics of the nonwoven
6 sheets and examples of how to make them.

7 Q. In summary, doctor, does the '372 application
8 provide sufficient disclosure to allow a person of skill in
9 the art to practice the subject matter of the asserted
10 claims of the '141 patent?

11 A. Yes, sir, I believe it does.

12 MR. AINSWORTH: Your Honor, we have no further
13 questions. We pass the witness.

14 JUDGE MCNAMARA: Thank you. Why don't we take
15 about ten minutes, and I will see you back here then.

16 And I gather, then, Mr. Swain, you'll be up.

17 MR. SWAIN: Yes, Your Honor.

18 JUDGE MCNAMARA: All right. Thank you. Ten
19 minutes.

20 (Whereupon, the proceedings recessed at 3:38
21 p.m.)

22 (In session at 3:48 p.m.)

23 JUDGE MCNAMARA: Good afternoon, everyone.

24 MR. SWAIN: Good afternoon, Your Honor.

25 JUDGE MCNAMARA: I think you have already passed

1 the witness, Mr. Ainsworth, so to speak.

2 All right. Mr. Swain.

3 Dr. Freeman, are you ready to start again?

4 You're muted.

5 THE WITNESS: Is it better now?

6 JUDGE MCNAMARA: Yes. Thank you.

7 THE WITNESS: Thank you.

8 JUDGE MCNAMARA: All right, Mr. Swain.

9 CROSS-EXAMINATION

10 BY MR. SWAIN:

11 Q. Good afternoon, Dr. Freeman.

12 Your Honor, I need to go right on to Brita

13 confidential information to start.

14 (Whereupon, the hearing proceeded in confidential
15 session.)

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Appx23561-23568
redacted in their
entirety

1 O P E N S E S S I O N

2

3 JUDGE MCNAMARA: We're back on the public record.

4 BY MR. SWAIN:

5 Q. Dr. Freeman, you agree with me there's no working
6 examples whatsoever in the '141 patent of a practicing
7 ligand-based filter that would meet the FRAP limitations of
8 the '141 patent?

9 A. Yes, sir, that's correct.

10 Q. And there are no working examples in the '141
11 patent of a practicing depth media filter that would meet
12 the FRAP limitations of the '141 patent.

13 A. Yes, sir, there are no working examples of that
14 kind.

15 Q. And, of course, the '141 patent has no teaching
16 of a mixed-media filter with a FRAP less than 350, correct?

17 A. There are no working examples of mixed-media
18 filters with a FRAP less than 350, if that's what you're
19 asking.

20 Q. There are no examples in the patent that teach
21 mixed-media filters that have a FRAP factor less than 350,
22 correct?

23 A. There are no working examples that are directed
24 towards mixed-media filter with a FRAP factor of under 350.

25 Q. My question is just a little bit different,

1 Dr. Freeman. I'm asking you, there are no examples in the
2 '141 patent that teach a mixed-media filter that have a FRAP
3 factor of less than 350, yes or no?

4 A. Let me make sure I understand the question so I
5 don't mislead you.

6 So you're asking if there's any examples of any
7 type in the '141 patent on mixed-media filters that could
8 meet the FRAP limitation; is that correct?

9 Q. I'm asking you, of all the examples that work in
10 the '141 patent, there are none that actually teach a
11 mixed-media patent that has a FRAP under 350.

12 A. There are no working examples of that kind,
13 that's correct.

14 Q. Quite the contrary, the '141 patent in black and
15 white tells us that all the mixed-media filters that were in
16 Brita's possession -- we're talking about the inventors and
17 what they had -- all the mixed-media filters in their
18 possession failed to meet the FRAP limitation, correct?

19 A. Yes, sir, that's correct.

20 Q. Okay. And that's shown right here in the patent
21 at column 26, lines 55-67. No mixed-media filters tested
22 met the claimed FRAP factor range due to their inability to
23 remove particulate lead, correct?

24 A. Yes, sir, that's correct.

25 Q. And it's not surprising, sir, because the patent

1 tells us in the very next sentence, the formulations of
2 gravity-fed carbon blocks disclosed are unique in there
3 [sic] ability to meet the required FRAP factor.

4 That's what the patent tells us. Is that not
5 true, Dr. Freeman?

6 A. Those words are on the page there, yes, sir.

7 Q. Okay. And that's true of, not just the '141
8 patent, but all the parent applications to the '141 patent,
9 correct? They are limited just to carbon block filters,
10 correct?

11 A. All the working examples are carbon block
12 filters.

13 Q. And no disclosure of a mixed-media filter that
14 would have a FRAP factor below 350, correct, in any of the
15 parent applications?

16 A. There are no working examples of mixed-media
17 filters with a FRAP factor of less than 350.

18 Q. The reason the '141 patent and any of its parents
19 do not teach anything beyond a carbon block filter is
20 because the inventors themselves actually never invented or
21 reduced to practice a filter with a FRAP under 350 that was
22 non-carbon block, correct?

23 A. The inventors used the carbon block filters as a
24 medium to express their invention, and they understood that
25 it could be applied to other filter media, but their working

1 examples were carbon block filters.

2 Q. Correct. And all the actual reduction to
3 practice you discuss in your report and in your testimony
4 today and throughout the lab notebooks say all the ones that
5 have a FRAP under 350 are carbon block, correct?

6 A. Yes, sir, all of the working examples and the
7 reductions to practice we discussed today are carbon block
8 filters.

9 Q. And the '141 patent, in addition to only
10 describing -- only disclosing one type of working filter
11 that practices the invention, it only describes two types of
12 lead scavengers; isn't that right, Dr. Freeman?

13 A. You'll have to show me where that is because
14 there is disclosure of several -- in several places on the
15 lead scavengers.

16 Q. Okay. Well, let's -- I'll show you where I'm
17 looking. I'm looking at Table 1, which you discussed in
18 your testimony. Do you see the column here on the left, we
19 have mostly -- we have our working embodiments of the patent
20 on the left with the exception of P2-8 and P2-6. It gives
21 us the lead scavenger that they use. There's an Alusil and
22 an ATS. Do you see that?

23 A. Yes, sir, I do.

24 Q. Okay. Do you agree with me there's only two
25 types of lead scavengers disclosed here for the working

1 examples in the '141 patent, correct?

2 A. Yes, sir, there's only the two types that are
3 shown here in Table 1 that were used to formulate the
4 working examples.

5 Q. Sure. But there's dozens, maybe hundreds, of
6 additional chemicals that could remove or reduce lead in
7 drinking water, correct?

8 A. There are additional ones beyond the ones that
9 are shown here, and there's discussion of those elsewhere in
10 the specification.

11 Q. But no working examples of those, correct?

12 A. That's correct. The working examples have the
13 lead sorbents that are listed here in Table 1.

14 Q. Okay. Let's move to the next column of Table 1
15 when we're talking about our practicing working examples
16 here.

17 One type of activated carbon in Table 1 under
18 carbon type, do you see that, Dr. Freeman?

19 A. Yes, sir, I do.

20 Q. Not just one type of activated carbon, one
21 particular size, 80 x 325 mesh, correct?

22 A. Yes, sir, that's correct.

23 Q. Okay. And you agree with me there are hundreds
24 of different types of carbon, activated carbon, coconut
25 shell, bituminous, and the list goes on and on, correct?

1 A. Yes, sir, there's a lot of choice in activated
2 carbon that's available on the market today.

3 Q. Not just in terms of type of activated carbon,
4 but also in mesh size, correct, in geometry, different size
5 of activated carbon, there's hundreds, right?

6 A. I wouldn't be surprised if that's the case, and I
7 think that would also have been the case at the relevant
8 time frame for this matter.

9 Q. Okay. And, again, all of these examples, these
10 are the ones that practice the '141 patent, none of these
11 are mixed-media, correct, Dr. Freeman?

12 A. None of the working examples are mixed-media.

13 Q. Okay. But your testimony is that a person of
14 skill in the art would, nonetheless, armed with just these
15 limited examples, would come with the considerable ability
16 and knowledge to take that big next step and make a
17 mixed-media filter that would meet the novel FRAP
18 limitation. They would be able to do that, correct?

19 A. Yes, sir, that's correct.

20 Q. And to take that next step, based on the
21 disclosure of the '141 patent, a person of ordinary skill in
22 the art, to make a mixed-media filter or any non-carbon
23 block filter, your testimony, Dr. Freeman, is that would be
24 akin to one skilled in the art searching for needles in a
25 haystack, correct?

1 A. No, sir. You've misconstrued my testimony there.

2 Q. Well, let's see what you said in your deposition.

3 Could I have Dr. Freeman's deposition at page 64,
4 line 19, through 65, line 11.

5 Okay. And you recall being deposed back in July,
6 I believe, Dr. Freeman. Do you remember that?

7 A. Yes, sir, that's correct.

8 Q. And it was by a gentleman who is older and wiser
9 and sometimes more handsome than I, but it was Mr. Gargano
10 who asked you:

11 Okay. Now how would a person of ordinary skill
12 in the art do that with respect to mixed-media filters when
13 there's not a single mixed-media filter example disclosed in
14 the '141 patent that achieves a FRAP factor below 350?

15 Just yes or no? Do you remember being asked that
16 question at your deposition, Dr. Freeman?

17 A. Yes, I did.

18 Q. And your answer to that question was:

19 So I think it -- a person of ordinary skill in
20 the art would come with a lot of background about
21 performance of prior mixed-media. And seeing that the
22 components were being used in the specification examples
23 here gave FRAP factors and those geometries that are set
24 forth gave the FRAP factors that -- that met the claim 1
25 limitation, a person of ordinary skill in the art could use

1 that information, then, to pick, if you will, the needles
2 out of the haystack of mixed-media and other formats to be
3 able to practice the invention.

4 Dr. Freeman, did I read your answer in your
5 deposition correctly?

6 A. Yes, sir.

7 Q. Okay. Let's --

8 JUDGE MCNAMARA: Mr. Swain, what's the date of
9 the deposition?

10 MR. SWAIN: July 13th, Your Honor.

11 JUDGE MCNAMARA: Thank you.

12 Q. I'd like to talk about some of the components of
13 the FRAP equation now, Dr. Freeman. Let's talk about volume
14 of filter media, one of the four variables of the FRAP
15 equation.

16 Could I have RDX-16.3 up?

17 On RDX-16.3, Dr. Freeman, you'll see on the left,
18 hopefully I have the FRAP equation there correctly, do you
19 see FRAP equals $V \times f \times C_e$ over $L \times 2$?

20 A. Yes, sir.

21 Q. Now you agree with me, to practice the patent, we
22 want to get that filter media volume -- we want to get that
23 as small as possible to get good filter performance,
24 correct? That's something we want low?

25 A. We want it to be as low as it could be without

1 compromising the other elements. Performance is not just a
2 single metric.

3 Q. You agree with me that the lowest that -- could I
4 have Table 2?

5 Here, again, we have our working embodiments.
6 The lowest volume of filter media that the inventors had was
7 89 cubic centimeters, correct, Dr. Freeman?

8 A. Yes, all of the working examples here used 89
9 cubic centimeters.

10 Q. There's no teaching in the patent or any other
11 embodiments that teach a practicing filter with a volume
12 less than 89 cubic centimeters, correct?

13 A. There are no working examples in the '141 patent
14 in this table with a volume other than 89 cc's.

15 Q. To be clear, Dr. Freeman, you agree with me
16 there's no limitation in the claim itself. Claim 1 has no
17 limitation on what the volume of filter media can be. It
18 can be 2 cubic centimeters, 10, or 20, so long as it meets
19 the FRAP limitation that practices claim 1, correct?

20 A. Yes, sir, there's no -- there is no values given
21 for the volume in the claim itself.

22 Q. Okay.

23 A. There is information --

24 Q. Please continue, sir.

25 A. -- about the volume and the specification

1 breathes life into the claims, and so you can't just look at
2 claims by themselves.

3 Q. Your testimony is that the filter volume can't be
4 0, but there's some lower bound to the volume of the filter
5 media baked into the claims that would limit the claims that
6 one could have and still practice the invention, but you
7 don't know what that is, do you, Dr. Freeman?

8 A. I think that's -- I think that's fair, that you
9 would like to get the volume as low as possible and meet the
10 other limitations of the FRAP. And so that would depend on
11 the other variables and on the materials you're putting --
12 you're putting into it.

13 And so to answer that question you'd have to look
14 at a specific example. And you can't just vary one of these
15 variables at a time because they are interrelated. As you
16 vary one, the others will change. So you're looking for an
17 optimum.

18 Q. That gives me a good segue here to discuss
19 something in your opening testimony, Dr. Freeman.

20 Could I have CDX-2.17?

21 Here you testified that this chart, Fig. 22, and
22 you also discussed Figs. 21 and 23, displayed the
23 interrelated nature of the FRAP equation, correct?

24 A. Yes, sir.

25 Q. Okay. And what this is, I just want to make sure

1 the record is clear about Figs. 21, 22 and 23, this is just
2 a graphical projection of the FRAP equation itself. It just
3 shows how the FRAP formula changes when you keep a couple
4 parameters constant and you vary one here, for example,
5 average filtration time unit, correct, minutes per liter?

6 A. Yes, that's correct.

7 Q. Okay. And these Figs. 21, 22, and 23,
8 Dr. Freeman, you're a teacher, these don't teach actually
9 how real-world gravity-fed filters would react when you
10 change the filtration time, unit time, and how that would
11 impact the volume or other aspects of the filter, correct?

12 A. What they're teaching in these three figures is
13 how those variables work together, and then, to do that,
14 that would inform a person of skill in the art about the
15 kinds of trends they should expect as they go out and make
16 other embodiments and test other embodiments.

17 Q. Dr. Freeman, you agree with me that you can't
18 just keep one filter or one variable constant and just cut
19 the others in half, right? They are all interrelated to
20 some degree, correct?

21 A. Yes, sir, that's correct.

22 Q. In the real world, with real gravity-fed filters,
23 including the ones in the patent, they would follow very
24 different trends here than what's shown on Fig. 22. This is
25 just the algebraic equation of the FRAP, right?

1 A. Well, what you're -- you know, this is showing
2 the interrelationship of the FRAP for unit filtration time f
3 and for effluent lead concentration C_e .

4 What would happen, as you moved along these
5 lines, is there would also be changes in V and L , and those
6 would be changing as well. And that's how you could get
7 long lines like this. And a person of ordinary skill in the
8 art would know that.

9 Q. Understood, but that's not shown in Figs. 21, 22,
10 and 23 how the other variables would actually react that
11 were held constant, correct?

12 A. Well, if you go between 21, 22 and 23, you see
13 them taken in pairs, all of them.

14 Q. Sure. Dr. Freeman, my question is a little bit
15 different.

16 JUDGE MCNAMARA: Wait a minute. Mr. Swain, I
17 don't think he was finished yet.

18 MR. SWAIN: Sure. Apologies, Dr. Freeman.

19 JUDGE MCNAMARA: Dr. Freeman, were you finished?
20 What I got was, when Mr. Swain asked you about Figs. 21, 22
21 and 23, you started answering that they were shown in pairs,
22 the various factors, I think.

23 A. Yes. Yes, ma'am, and thank you.

24 Yes, so these figures show between them all of
25 the elements of the FRAP equation taken in pairs, and so you

1 can -- as you manipulate the pairs of them, the other
2 variables are also going to be varying in the filters that
3 you would make. And so this is designed to show how one
4 could move the FRAP value with specific combinations of, for
5 example, lead concentration and filtration time. It's not
6 saying that the other variables aren't changing, because a
7 person of skill in the art would know that that was the
8 case.

9 Q. Okay. Thank you, Dr. Freeman. If I understand,
10 again, this is how one can maintain a FRAP under 350 just
11 when they have certain variables in filters that they have
12 made, correct?

13 A. That's correct. And those variables are the
14 filtration unit time, the effluent lead concentration at the
15 end of lifetime, the lifetime, and the volume of the filter.

16 Q. And we looked at, I believe, nine embodiments
17 within the '141 patent and several others in the parent
18 application. They're not shown on this chart, correct, in
19 Figs. 21, 22, and 23, the embodiments shown in the
20 specification are not shown on this chart, correct?

21 A. I believe that's correct.

22 Q. Okay. And the diamond and the circle and the
23 triangle shown here on Figs. 21, 22, and 23, that's just
24 denoting the different lines; those aren't actual
25 datapoints, correct?

1 A. That's my understanding. I think that's the way
2 a person of skill in the art would interpret it.

3 Q. Okay. I'd like now to talk -- dive back into
4 volume, Dr. Freeman. To get a lower volume than the 89
5 that's in the '141 patent, a person of ordinary skill in the
6 art would need to survey different combinations of materials
7 and shapes and so forth to see where they could come out to
8 get a FRAP value of under 350, correct?

9 A. Yes, sir, that would be one way of going about
10 it.

11 Q. Okay. You don't know, Dr. Freeman, your
12 testimony is you don't know how long that would take,
13 correct?

14 A. Well, you would start with the inventive examples
15 in the '141 patent and then work outwards from there. And
16 so that process could be very fast, in my opinion, and you'd
17 have a head start based on the teachings of the '141 patent.

18 Q. Sure. And you say this from the basis of someone
19 who has never designed a gravity-fed water filter that
20 reduces lead in drinking water, correct?

21 A. I've never designed a gravity-fed water filter
22 that reduces lead in drinking water. I've designed filters
23 all of my professional life and I have a ton of experience.
24 And I can tell you that we're making these kinds of
25 decisions -- a person of skill in the art would be able to

1 make those kinds of decisions and tradeoffs and would not
2 have to undergo an undue amount of experimentation to make
3 that change.

4 Q. Did you ever try to make a filter that has a FRAP
5 under 350 with a volume under 89, Dr. Freeman? Did you
6 undertake that effort?

7 A. I have not made any filters myself for this
8 matter.

9 Q. Thank you, Dr. Freeman. I'd like to talk now
10 about flow rate, another variable of the FRAP equation.

11 RDX-16.4.

12 Again, we have average flow rate at the top of
13 the FRAP equation, Dr. Freeman. This is something that the
14 lower it goes, the average flow rate, that's the faster the
15 water is going through the filter; is that correct?

16 A. Yes, sir, that's correct. It's the number of
17 minutes to filter a liter of water.

18 Q. Sure. And to get a filter that practices the
19 '141 patent, you want to have as fast of a flow rate as
20 possible, correct?

21 A. Yes. If you have a high flow rate, then the
22 device can filter a lot of water in a short amount of time,
23 and that has to be balanced against changes in the other
24 variables.

25 Q. And there's no limit in claim 1 on the average

1 flow rate a filter would have to have in order to have a
2 FRAP of 350, correct?

3 A. That's correct. There's no numerical limit
4 explicitly given in claim 1. There would be a limit on the
5 flow rate that would be imposed by essentially nature, by
6 science, that would enable a filter to meet the FRAP
7 limitation.

8 Q. And sitting here today you can't tell me what
9 that lower bound is, can you, Dr. Freeman?

10 A. It would depend on the details of the materials
11 that you put into the filter and how it was organized and
12 the volume of it. And so you'd need, you know, taken as a
13 naked hypothetical, I can't answer that question, but if we
14 were to look at specific examples, then, you know, you start
15 to be able to answer questions like that, but you can't just
16 take one of these variables and say, well, I'm going to
17 change it and everything else is going to be just the same.
18 It doesn't work -- the science doesn't work that way and a
19 person of skill in the art would know that.

20 Q. You can't just predict on paper what's going to
21 happen to the other variables, correct?

22 A. You could model these filters and make
23 predictions, but my experience with making filtration --
24 filtration separation membranes is that it's often faster to
25 go to the lab and make the measurements, but it's not

1 like -- they don't follow fundamental science principles
2 that are well-known.

3 Q. Okay. Let's look at the best flow rate the
4 inventors of the '141 patent could achieve.

5 Could I have Table 5 back up again, Mr. Campos?

6 Do you agree with me, yes or no, Dr. Freeman, the
7 best flow rate that the inventors of the '141 patent could
8 achieve is that 4.2 minutes per liter of PT 3-13, correct?
9 And there's also a 4.2 in PT 3-4. So those are your two
10 fastest filters. That's as fast as the inventors could go,
11 correct?

12 A. Those are the fastest flow rates that are shown
13 here in these examples in Table 5, I believe.

14 Q. Okay. And FRAP in claim 1, you agree with me,
15 could cover gravity filters that are much faster than this,
16 correct? It could cover a gravity-fed filter with a flow
17 rate of 3 minutes per liter so long as the FRAP is 350,
18 correct?

19 A. Potentially, as long as everything else was
20 balanced -- the volume, the lifetime, and the effluent lead
21 concentration -- to get the FRAP value less than 350.

22 Again, if you just change one variable, like f ,
23 the way you would change that is by changing the pore size
24 in the carbon filter. That's going to then change the lead
25 removal and potentially affect the lifetime. And so you

1 have to -- you have to weigh these factors together as you
2 make those kinds of changes.

3 Q. If I took PT 3-13 that has a volume of 89 cubic
4 centimeters, what would happen to my lifetime flow rate in
5 Ce?

6 A. I'm sorry. What's the question?

7 Q. Let's look at embodiment PT 3-13. I take my
8 filter media. I cut it in half. I'm from 89 down to 44.
9 What is the impact on the lifetime flow rate of effluent
10 lead on that filter?

11 A. And you've made no other changes to it?

12 Q. No, sir.

13 A. So if you reduce the volume by half and haven't
14 changed anything about the format or the layout, what that
15 will do is increase the flow through the filter. In the
16 simplest case it would double it. It might not necessarily
17 double it depending on the particular geometry.

18 And then as the water flowed faster through the
19 thinner -- through the thinner filter, it would have less
20 contact time of that water with the -- with the filter
21 media, which would, for example, if the lead scavenger --
22 potentially give the lead scavenger less time to remove the
23 soluble lead, which could drive Ce up. It could also -- it
24 would also reduce the capacity of the lead scavenger by
25 half, which would potentially change the lifetime L.

1 So these are well-known science principles. And
2 so as you change one variable, the others move in reaction
3 to it. And so you have to be cognizant of that when you're
4 going about designing the filters. And a person of ordinary
5 skill in the art would be aware of these relationships.

6 Q. I'm asking you how much. Do you have a specific
7 number, if any, of the variables would change if I cut the
8 volume in half?

9 A. Sure. So if you reduce the volume by half,
10 everything else about that filter, its shape and format, the
11 materials in it held constant, then the simplest case would
12 be that that would double the flow rate. Doubling the flow
13 rate, then, would have other implications. It would change,
14 potentially change the time that the lead scavenger had to
15 remove soluble lead, and the -- and the amount of lead
16 scavenger would be potentially reduced by half.

17 Those variables would push up Ce and/or reduce L.
18 There would be a tradeoff there.

19 Q. Would that resulting filter still have a FRAP
20 under 350, Dr. Freeman?

21 A. It potentially could. It would depend on the
22 nature of the activated carbon and the lead scavenger in it
23 and how they respond to having to deal with a lot higher
24 flow rate of water passed them and with having a lot less
25 total capacity. And that would depend on the individual --

1 individual components that were in the -- that were in the
2 filter.

3 Q. And the only way to know that how the lifetime
4 changes and how the Ce would change, you'd have to test
5 that, correct?

6 A. The easiest way to do it would be to test it. As
7 I indicated, the science here is quite old. We teach the
8 science for how these variables move --

9 Q. Dr. Freeman, I'm sorry, my question -- I'm sorry
10 to interrupt. My question is a yes or no.

11 JUDGE MCNAMARA: Hold on. Stop, please. You're
12 talking over one another.

13 Mr. Swain, let Dr. Freeman finish, and then if
14 the question was not answered, come back around then,
15 please.

16 I'm sorry. Ms. Kinkade, would you read back what
17 Dr. Freeman said and then we'll go from there.

18 (Record read.)

19 JUDGE MCNAMARA: Dr. Freeman, would you like to
20 finish?

21 A. Thank you.

22 So we teach the science of how the performance of
23 particle beds and filter media like this, how the flow rate
24 is affected by changes, like changing the volume of the
25 filter bed, and we also teach how the variables like the

1 amount of lead that could be taken up, how that would
2 change.

3 I taught this for 30 years in undergraduate
4 chemical engineering. And a person of skill in the art
5 would know the underlying science that would govern these
6 relationships and would be able to apply that science to
7 allow them to understand in general how these variables
8 would change. And that background science provides a good
9 intuition, and then you go into the laboratory and make the
10 filter to ultimately determine its performance.

11 Q. Thank you, Dr. Freeman. Your whole explanation
12 there, that's coming from one skilled in the art. That's
13 not what's taught in the patent, correct?

14 A. That would be -- that would be the way a person
15 of skill in the art would understand what's in the patent.

16 Q. Okay. I'd like to talk next about the next
17 variable in the FRAP equation, lead effluent. You agree --

18 If I could have RDX-16.5, Mr. Campos?

19 Okay. There's our third numerator variable Ce.
20 That's the variable we also want low, right, to get a good
21 FRAP. We want that as low as possible, correct?

22 A. You want it low, at least low enough to meet the
23 water quality standard. Whether you want it much lower than
24 that or not, you know, would depend on factors, it depend on
25 other factors, but you'd want it at least as low -- low

1 enough to meet the water quality standard that you're trying
2 to satisfy.

3 Q. Sure. There's not a value in claim 1, though.
4 There's not a value requirement of effluent lead
5 concentration that's explicitly given in claim 1, is there?

6 A. There is not an explicit value of effluent lead
7 concentration given in claim 1. The patent is about lead
8 reduction to meet the new NSF 2007 lead reduction standard,
9 and that value is 10 parts per billion.

10 Q. Okay. Dr. Freeman, I could have a lead effluent
11 that could be around 2 parts per billion Ce in claim 1 and
12 still be met, correct?

13 A. I'm sorry. Could I get the question again?
14 Excuse me.

15 Q. Sure. I can have a lead -- I'm going to ask a
16 different question, Dr. Freeman. I withdraw the last one.

17 I could have a lead effluent less than one, maybe
18 even .1, and you could still satisfy claim 1 of the FRAP
19 equation, correct?

20 A. With a Ce value of .1 ppb, if the other variables
21 in the FRAP equation were lined up such that they supported
22 a value of less than 350, then that would be the case.

23 Again, as you lower the Ce, you have to ask how
24 is that being done. And as you make a change to the filter
25 to lower the Ce, what does it do to the other variables.

1 And, again, a person of skill in the art would know how to
2 manipulate those -- understand how those variables change.

3 Q. Can I have Table 5 again, Mr. Campos, of the '141
4 patent?

5 Do you agree with me, Dr. Freeman, a yes-or-no
6 question, the lowest Ce value of the embodiments in Table 5
7 was 1.3 parts per billion, correct, there in PT 3-4,
8 alternate housing?

9 A. Yes --

10 Q. That's the lowest working --

11 A. Excuse me.

12 Q. Go ahead. I'll ask the question for us. Go
13 ahead, Dr. Freeman.

14 A. I'll let you go.

15 Q. Okay. Let's try this again.

16 Dr. Freeman, yes or no, do you agree with me that
17 the lowest effluent lead value Ce of all the working
18 examples in the '141 patent is 1.3, correct?

19 A. Yes, sir, the lowest value in Table 5 here is 1.3
20 parts per billion, and that's the Ce at the end of the
21 lifetime of the filter, after 40 gallons of filtration.

22 Q. And we're talking about PT 3-4, alternate housing
23 embodiment, correct?

24 A. Yes, sir.

25 Q. Let's talk about the last variable of FRAP.

1 Let's talk lifetime.

2 Could I have RDX-16.5?

3 Dr. Freeman, do you agree that, to meet claim 1
4 of the '141 patent to get that FRAP lower, we want that
5 lifetime longer, we want it higher, correct?

6 A. In principle, if you need a certain lifetime in
7 these devices, and so you want the longest lifetime that you
8 could get that would be consistent with not moving the other
9 variables in the FRAP equation in direction such that they
10 would take you out of the desired range of the FRAP value.

11 Q. There's no express limit on the value of lifetime
12 in claim 1, correct? We could have a lifetime of 20 or 60
13 or 120, so long as the other variables are met and we have a
14 FRAP under 350, there's nothing stopping us from having a
15 filter with those lifetime values in practicing claim 1,
16 correct, on paper?

17 A. As you change the lifetime, you're doing that by
18 changing the characteristics of the filter. And the
19 material that goes into making it up, the volume and so
20 forth, and so you're moving the other variables as well.

21 And so you could make changes to increase the
22 lifetime, but one thing that -- one way you might do that
23 is, say, to increase the volume of the filter media.

24 And so that's a simple way to understand how
25 those two variables work together. If you increase the

1 volume and it lowered the flow rate, so that would drive f
2 up. And so these values, you have to -- you have to take
3 them together. You can't just isolate one and say, well,
4 I'll change that one independently. It's not how the
5 science works.

6 Q. Understood, Dr. Freeman. Just a yes-or-no
7 question. We could have a lifetime that's been validated
8 for 120 liters, right, and that's still possible, at least
9 on paper, to have a product that practices the '141 patent,
10 so long as I get the FRAP under 350, correct? There's
11 nothing -- there's no upper limit to lifetime in claim 1,
12 correct?

13 A. Well, there will be an upper limit, because as
14 you -- as you take steps to change the filter to increase
15 that lifetime, you're at some point going to be changing the
16 properties and the composition of the filter in ways that
17 are going to drive the flow rate to be very slow or drive
18 the volume of the filter up to the point where the FRAP
19 limitation won't be met. You can't use -- you can't have an
20 infinite lifetime --

21 Q. Dr. Freeman -- go ahead, Dr. Freeman.

22 A. -- and have the -- and expect that the FRAP value
23 is simply going to always remain below 350.

24 Q. Okay. What I'm asking you, Dr. Freeman, is a
25 little bit more direct, and I want a yes or no answer to

1 this.

2 It is possible from your viewpoint as one skilled
3 in the art to have a filter that has a lifetime of 120 and
4 still practice claim 1 of the '141 patent, correct?

5 A. I believe that would be possible as long as the
6 other variables were not moved so far out of range that they
7 took the FRAP value above 350.

8 Q. Okay. The best and only lifetime, though,
9 Dr. Freeman, that the inventors were able to get and still
10 practice claim 1 was 40 gallons, correct?

11 A. The lifetime that they were testing against in
12 their working examples was 40-gallon lifetime, that's
13 correct.

14 Q. There are no filter working embodiments with a
15 lifetime of anything over 40 in the '141 patent, correct?

16 A. They were testing to a lifetime of 40 gallons in
17 all of the working examples, yes, sir.

18 Q. Okay. Let's talk now about the whole equation
19 now, Dr. Freeman, about the FRAP equation itself. We can
20 stay --

21 Could I have claim 1 up of the '141 patent,
22 please, Mr. Campos?

23 Do you agree with me, Dr. Freeman, as written,
24 claim 1 requires one thing of the FRAP values. It needs to
25 be about 350 or less, according to that formula, correct?

1 A. With respect to FRAP, yes, sir, I agree with
2 that.

3 Q. If there's a FRAP of 2 would satisfy claim 1,
4 correct?

5 A. Yes, sir, if you could make a filter like that,
6 that's correct.

7 Q. And a FRAP of 1 would satisfy claim 1, correct?

8 A. If such a filter could be made, that would be
9 correct, yes, sir.

10 Q. And even a FRAP of 0.1 would satisfy claim 1,
11 correct?

12 A. Yes, sir, if one could put together a filter or
13 make a filter that had that FRAP value, that would satisfy
14 claim 1 with all the other attributes of claim 1.

15 Q. Understood. The very best, though, the inventors
16 had in their embodiments in their possession in the '141
17 patent, the best FRAP they could do was 6.7, correct?

18 A. I believe that was the lowest value in the
19 working examples that we were just looking at.

20 Q. Sure. Dr. Freeman, you mentioned FRAPs of 2, 1,
21 and 0.1, maybe if one could create that, it would satisfy
22 claim 1, but, Dr. Freeman, your testimony is you're not even
23 sure if FRAPs under 5 were even possible at the time of the
24 invention using the existing variable materials, correct?

25 A. I think you have to always consider the materials

1 and how you would organize them in a filter as to what would
2 be possible.

3 And so it's very hard to answer abstract
4 hypothetical questions like that, because the variables
5 change and they are interrelated with one another.

6 Q. Okay. You, as one skilled in the art -- I'll ask
7 the question again.

8 As one skilled in the art at the time of the
9 invention of the '141 patent, were filters having a FRAP of
10 less or equal to 5 obtainable in the art?

11 A. I don't know the -- I haven't seen a filter of
12 less than 5 at the time that I was deposed. I've since come
13 to learn that there are filters in this matter that go down
14 to .02.

15 Q. Okay. At the time of the invention, Dr. Freeman,
16 though -- I'll withdraw the question.

17 Dr. Freeman, I do want to talk a little bit more
18 about the disclosure of the '141 patent.

19 Could I have CDX-2.12 and CDX-2.25 up, please.

20 Okay. Now, Dr. Freeman --

21 JUDGE MCNAMARA: Pardon me. I think they need to
22 be blown up a bit.

23 Q. Let's do one at a time. Could I just have
24 CDX-2.12?

25 Dr. Freeman, if I understood your testimony on

1 CDX-2.12, this is one of the disclosures of the full scope
2 of the invention of claim 1 of the '141 patent, correct,
3 where it's disclosed in the '141 patent?

4 A. Yes, sir.

5 Q. Okay. And here it's basically the claim
6 language, correct?

7 A. Yes, sir, very close to it.

8 Q. Okay. Let's look at the other portion you cite
9 to in the '141 patent.

10 Could I have CDX-2.25?

11 This is the other part of the specification you
12 cite to, these three portions, correct, on CDX-2.25?

13 A. Yes, sir, that's correct.

14 Q. Okay. And in order to get non-carbon block
15 filters, in order to fill in that piece of the puzzle from
16 these three cites in the specification where it discusses
17 other possible embodiments, you have to use one of skill in
18 the art, correct, that there's no further actual disclosure
19 or discussion of mixed-media or other non-carbon block
20 filters in the patent, correct?

21 A. I'm not -- I'm not sure that that's the case.
22 There's a lot of disclosure in the patent. It's certainly
23 disclosed here, but there's a lot of discussion of different
24 types of filter media throughout the patent. I'm not sure
25 that these are the only -- the only places. These are

1 exemplary places where it's discussed.

2 Q. Okay. Again, no working examples. No explicit
3 instructions of an actual working mixed-media or nonwoven or
4 depth media filter that would practice the '141 patent,
5 correct?

6 A. Yes, sir, the working examples were carbon block
7 filters.

8 Q. Okay. Dr. Freeman, let's set 112 aside for a
9 moment. I want to now talk to you about your expert reports
10 in this litigation.

11 Now I want to -- and it may touch on some items
12 that you did not discuss in your testimony today.

13 Dr. Freeman, you understand you're here per a
14 trial subpoena, correct?

15 A. Yes, sir.

16 Q. I'm very glad you're here because I recall you
17 testifying you would move heaven and earth to be here, and
18 I'm very glad you're here.

19 A. Yes. Well, and I'm glad to be here as well as
20 long as we're all well.

21 Q. I agree, Dr. Freeman. I want to take time back
22 to May 24th, 2022 when you submitted an expert report in
23 this investigation. Do you remember that?

24 A. Yes, sir.

25 Q. Okay. Can I have RX-878 up, please, Mr. Campos?

1 Okay. This is your initial expert report here
2 shown on the screen. That's your name, and hopefully we can
3 show the signature as well just to make sure you see that
4 it's "the real McCoy."

5 Is this your opening report, Dr. Freeman?

6 A. Yes, sir, I believe so.

7 Q. Okay. If I count correctly, Dr. Freeman, in your
8 opening report you provided at least 35 reductions to
9 practice, 35 filters, that practice the '141 patent,
10 correct?

11 A. Yes, sir, that's correct.

12 Q. Okay. And to have an actual reduction to
13 practice of the patent, you have to practice a claim,
14 correct, it -- that filter would have to meet all the claim
15 limitations of the asserted claims, correct?

16 A. Yes, sir, that's my understanding.

17 Q. Okay. Could I have RDX-16.7, please.

18 Due to the magic of preparation, Dr. Freeman, we
19 have all 35 filters up here on the board in RDX-16.7. Do
20 you agree those are the 35 filters you opined practice the
21 claims of the '141 patent in your opening report, correct?

22 A. Mr. Swain, I'm going to have to take your word
23 for it or we're going to be here a while going through them
24 one by one.

25 Q. Well, if something is incorrect, I'm sure counsel

1 or yourself will quickly correct me, but we took a lot of
2 time to put this together. So if you see something wrong,
3 Dr. Freeman, please let me know.

4 A. Yes, sir. Fair enough.

5 Q. Okay. Opining that these 35 filters met the
6 claims of the '141 patent, you did so under Brita's
7 construction and many other construction that was disclosed
8 in this investigation, correct?

9 A. Yes, sir. The Claim Construction Order had not
10 yet been decided.

11 Q. Okay. And your opinion was that all of these
12 filters, all 35 of them, practice the claims of the patent
13 per Brita's constructions and Respondents' constructions at
14 the time, correct?

15 A. Yes, sir. I tried to consider all of the
16 possible constructions that were in play.

17 Q. Thank you, Dr. Freeman. I'd like to take item A
18 here, the first tranche, if you will, of 7, the formula 13
19 and 14 filters.

20 Do you remember opining on those, Dr. Freeman?

21 A. Yes, sir, a little bit. It's been a while.

22 Q. Okay. And for all seven of those filters, to
23 arrive at the FRAP value, Dr. Freeman, isn't it true, in
24 order to get the average flow rate you used three or less
25 samples out of 151 liters, correct?

1 A. Yes, sir. I believe in these the liter-by-liter
2 data were not available.

3 Q. Okay. And despite liter by liter not being
4 available, you testified under oath and under all
5 constructions of average flow rate that you could conclude
6 that the FRAP was under 350, correct?

7 A. I would -- I would phrase it just a little bit
8 differently, that the FRAP is under -- is under 350 under at
9 least one of the claim constructions that were at issue
10 because they had diverged quite a bit, as I'm sure you
11 recall. And so it was not until the Claim Construction
12 Order came down that that finally got clarified.

13 Q. I'm not quite sure what you mean, Dr. Freeman.
14 Let's actually look at your report at one of these examples.

15 Could I have RX-878 at 20 to 21, paragraph 63,
16 Mr. Campos?

17 Okay. Here's your opinion on embodiment 13-2
18 where you calculated a FRAP of 135.8. Do you see that,
19 Dr. Freeman?

20 A. Yes, I do.

21 Q. And here you calculated the average filtration
22 time, *f*, of 5.4 minutes per liter, averaging these three
23 sample points together, correct?

24 A. Yes, sir, that's correct.

25 Q. Okay. And under oath you testified that this was

1 a practicing filter of the '141 patent under both
2 constructions, correct?

3 A. Under some of -- some construction that was being
4 proposed, that's correct.

5 Q. I thought we discussed, Dr. Freeman, we just
6 discussed that your report was under both constructions,
7 correct?

8 A. That's correct. It was under Brita's proposed
9 construction as well as Respondents', and those
10 constructions were quite different.

11 Q. Okay. But regardless of what they are, you
12 opined that the FRAP limitation was met by 13-2, correct?

13 A. Yes, that's correct.

14 Q. Okay. And I do want to note here that there's a
15 Ce value here of 22.6, is there not, Dr. Freeman?

16 A. That's correct.

17 Q. And that's well over 10 ppb, correct?

18 A. It is.

19 Q. Okay. And you've calculated a FRAP value using a
20 lifetime of 40, even though this filter went over 10 ppb,
21 correct?

22 A. Yes, that's correct.

23 Q. Okay. So let's summarize at least the flow rates
24 we've discussed so far.

25 Could I have RDX-16.9?

1 Okay. Here, Dr. Freeman, are the seven filters
2 that were in the formula 13 and 14 that you opined met the
3 FRAP limitation under both constructions and how many sample
4 points you used for each. You used three for six of them
5 and two for one of them, correct?

6 A. Yes, sir, that's correct.

7 Q. Okay. Let's talk about some other reductions to
8 practice you discuss.

9 Now do you agree with me that I counted
10 personally over ten instances of the 35 where the end of
11 lifetime Ce was over 10 ppb, correct?

12 A. I'll take your word for it. There were several.

13 Q. Okay. And despite the Ce being over 10 ppb, you
14 were able to calculate a FRAP of that filter under both
15 parties' constructions, correct?

16 A. Yes, that's correct.

17 Q. Okay. And that included, if I could have your
18 own demonstrative, CDX-2.48, that included there are 17
19 filters listed here for the '372 patent, and here you have
20 at least five embodiments you say practice the patent, but
21 they have Ce's over 10, correct?

22 A. Yes, sir, that's correct.

23 Q. Okay. And you believe those Ce's were calculated
24 correctly by the inventors, correct?

25 A. I have no reason to doubt that.

1 Q. And those Ce's were reached by using the
2 challenge water, in CDX-2.48, using the challenge water of
3 the '141 patent, correct?

4 A. Yes, that's correct.

5 Q. Okay. So let's look at the ones that went over
6 10 for the Ce value.

7 Could I have RDX-16.10?

8 Sir, again, through the magic of preparation,
9 this is your own report, RDX-16.10, lists out the filters
10 that have a Ce over 10 ppb that you nonetheless opined
11 practice the claims of the '141 patent under both parties'
12 constructions, correct?

13 A. Yes, that's correct.

14 Q. And in addition to these shown on RDX-16.10,
15 which is either 10 or 11, there's another 12 or so that went
16 over 10 ppb during the filter's testing, correct?

17 A. There were a number of them that did that, yes.

18 Q. Okay. Can I have RDX-16.11?

19 Again, magic of preparation, Dr. Freeman, they
20 are listed here. We have several more filters listed on
21 RDX-16.11 that went over 10 ppb in their effluent testing,
22 yet you opined that they have a lifetime under both parties'
23 constructions and meet the claims of the '141 patent,
24 correct?

25 A. Yes. I opined that they had FRAP factors less

1 than 350.

2 Q. And that includes PA 3-5, the PA 3-5 filter,
3 which is an embodiment expressly disclosed in the '141
4 patent, correct?

5 A. Yes, sir. I believe we were looking at that one
6 in Table 5 earlier.

7 Q. Okay. We can take that down. Could I have
8 CDX-2.48 back up again?

9 Now, Dr. Freeman, just to revisit your testimony,
10 your testimony is that the Ce values here shown on CDX-2.48
11 were obtained using challenge water according to claim 1 of
12 the '141 patent, correct?

13 A. Yes, sir, that's my understanding.

14 Q. And there are certain requirements of the '141
15 patent claim that require 90 to 120 soluble lead and 30 to
16 60 particulate lead. Do I have that correct?

17 A. I believe so.

18 Q. Let's take a look at just one of these. Let's
19 look, for example, at FA 32 and your opinion on that.

20 Could I have RX-878C at paragraph 101, please,
21 Mr. Campos.

22 Okay. And here's FA 3-2 from your opening report
23 that a person of skill in the art would understand that
24 filter FA 3-2 is an actual reduction to practice of an
25 embodiment of the invention because it is a gravity-fed

1 water filter, comprising a filter media including at least
2 activated carbon and a lead scavenger and achieved a FRAP of
3 27.2, correct?

4 A. Yes, sir.

5 Q. Okay. And this embodiment actually appears in
6 the parent application as well, does it not, Dr. Freeman?

7 A. I don't remember, but it may well have.

8 Q. Sure. Let's take a look at the parent,
9 Mr. Campos.

10 Could we have RX-964 at Table 8? And could I
11 have FA 3-2 blown up.

12 You notice on FA 3-2 in Table 8 of the '372
13 parent application, neither the colloidal lead nor the
14 soluble lead was tracked, correct?

15 A. What's being tracked is the influent and effluent
16 lead in this case --

17 Q. And no disclosure of what the actual --

18 A. -- supported. I'm sorry. Yes.

19 Q. Okay. I don't want to cut you off. Go ahead.

20 JUDGE MCNAMARA: What were you saying,
21 Dr. Freeman?

22 Again, Ms. Kinkade, did you get Dr. Freeman's
23 testimony before there was crosstalk?

24 (Record read.)

25 A. Yes, what's being reported here is the influent

1 and effluent lead concentration.

2 Q. Nowhere in the patent is the actual influent
3 soluble lead at any of the test points tracked or any of the
4 influent particulate lead tracked at any point, correct?

5 A. For this particular example?

6 Q. Yes, sir.

7 A. Not that I'm aware of. And I would say reported
8 because there were measurements, as you know, from the
9 testimony of the inventors where they reported a subset of
10 their data in the patent, and so we'd have to go back and
11 look if they -- if they measured it but just in this summary
12 chose not to report it.

13 Q. Let's see what they actually did track in their
14 notebooks, Dr. Freeman.

15 Could I have Dr. Knipmeyer's lab notebook,
16 CX-108C?

17 Can I have FA 3-2 blown up? Or I'll have the
18 whole thing looked at.

19 Dr. Freeman, you looked at lab notebooks in your
20 investigation. Do you recall looking at Dr. Knipmeyer's lab
21 notebook?

22 A. Yes, I did.

23 Q. And, again, you see Dr. Knipmeyer nee Chambers
24 signature here, correct?

25 A. Yes, that's correct.

1 Q. And the signature over top of this data means
2 that that data is true and accurate, correct?

3 A. That would be my understanding that she had put
4 the data in and then signed over it to make it a permanent
5 part of her laboratory notebook.

6 Q. And where she signed the accurate and true
7 information of embodiment FA 3-2 she did not track -- Brita
8 did not track the influent soluble lead nor the influent
9 particulate lead at any point during the actual testing,
10 correct?

11 A. Ah, okay. I'm sorry, Mr. Swain, I think I -- I
12 think I understand. To see where those -- there's more
13 detail about the characterization of water, you have to go
14 back to the data where they made the tanks of the source
15 water for these tests, and there, there was a lot more
16 information of the type that you're -- I think you're
17 looking for.

18 Q. Sure. And I think if we look back, they started
19 with one-for-one compliant water, correct? If we looked
20 back, we would find that the soluble and particulate lead
21 levels of that water at the start of the test, correct?

22 A. They were measuring that, to my understanding, at
23 the beginning of the -- when they started using a given
24 tank.

25 Q. Okay. But they didn't test it as they continued

1 to test the filters, including FA 3-2, didn't record it,
2 didn't test it, correct?

3 A. I don't remember seeing intermediate points
4 tested. My understanding was that when they made a tank
5 they tested it, and then, in accordance with NSF standards,
6 they used that tank within 24 hours.

7 Q. Okay. They assumed -- if I could have the next
8 portion blown up -- Brita and Dr. Knipmeyer assumed that
9 there was only -- that there was 30 percent particulate in
10 the influent number, correct?

11 Could I have that portion blown up, Mr. Campos?
12 It's right below the signature. A little bit above. There
13 we go.

14 The first sentence in Dr. Knipmeyer's signed and
15 sworn lab notebook, the calculation for particulate removed
16 was made assuming 30 percent particulate in the influent,
17 correct?

18 A. That's what's written there.

19 Q. Okay. And it's okay, is it not, Dr. Freeman, to
20 assume that the one-for-one challenge water is met when it
21 was tested at the beginning and not tested again throughout
22 the test, correct?

23 A. That was the -- that was the point of the NSF
24 standard was to provide instructions to make challenge water
25 that was stable over a period of at least 24 hours, and so

1 that formed the basis of the recommendation from NSF to the
2 research community. And to my understanding that was what
3 Brita was following.

4 Q. Okay. The same is true for all these filters on
5 CX- .109, foxtrot alpha 11, foxtrot alpha 13, foxtrot alpha
6 23, foxtrot alpha 24, foxtrot alpha 32, foxtrot tango 21,
7 and foxtrot tango 23, correct, Dr. Freeman?

8 A. I'm sorry. What's the question?

9 Q. Sure. Let's back out and just show the page.
10 There's no influent lead, particulate lead, actually tracked
11 at each sample point here, correct? There's just the
12 assumption for all the embodiments on CX-108.109, there's
13 just the assumption that the particulate lead levels were
14 met, correct?

15 A. My understanding is that they measured the
16 particulate lead level each time they made a new tank of
17 challenge water and then used that within 24 hours, which is
18 consistent with NSF guidance for this test.

19 Q. The actual colloidal and particulate amounts,
20 colloidal and soluble leads, weren't actually recorded,
21 correct, they were just assumed?

22 A. I haven't -- I don't recall seeing values at
23 every -- at each one of these points, but they were
24 conducting the test from that point of view consistent with
25 the NSF standard.

1 Q. Consistent with NSF 53 standard, correct?

2 A. Yes, sir.

3 Q. Okay. A standard that you have no prior
4 experience with, correct?

5 A. It's a standard that I have not worked with
6 before this matter, but I have extensive experience working
7 with standards from NSF and other professional organizations
8 and understand how to implement them and how to interpret
9 them and how to use them.

10 Q. Let's look at another lab notebook source for the
11 embodiments in the parent application.

12 Could I have CX-109.112?

13 Here we have three more. There's four filters
14 tested here, but three of them are ones that you relied on
15 in the parent application, correct, Dr. Freeman? That's
16 papa alpha 11, papa alpha 21, and papa tango 21.

17 Do you see those, Dr. Freeman?

18 A. Yes, I see those.

19 Q. And, again, no tracking, no actual measurement of
20 the soluble or colloidal lead at the 3L, 76L or 151L mark,
21 correct?

22 A. Those measurements aren't shown here that I'm
23 aware of.

24 Q. Okay. Those measurements aren't shown; they are
25 assumed, correct?

1 A. Where are you getting that?

2 Q. Let's go to the right of papa tango 21,
3 Mr. Campos, a little bit. There we have it again.

4 Dr. Knipmeyer's note that the percent particulate
5 calculated assumed 30 percent particulate in the influent,
6 correct?

7 A. I see that written there.

8 Q. Okay. And, once again, three more embodiments,
9 PA 11, PA 21, and PT 21, where it was assumed what the
10 influent colloidal and soluble lead were, correct?

11 A. I believe these in all cases they were making
12 these tanks and measuring those variables at the beginning
13 of the test, and then pursuant to NSF guidelines they could
14 use that tank within 24 hours without further testing.

15 Q. Okay. Last, let's look at CX-109.114, lab
16 notebook.

17 Again, another portion of the lab notebooks you
18 rely on, and here we have four more embodiments, papa alpha
19 12, papa alpha 23, papa alpha 33, papa tango 23. Do you see
20 those, Dr. Freeman?

21 A. Yes, I do.

22 Q. Okay. And nowhere in these four embodiments is
23 the influent soluble or colloidal lead actually measured at
24 the 3L, 76L, or 151L mark, correct?

25 A. I don't see that information here, that's

1 correct.

2 Q. Again, that's because the inventor of the '141
3 patent merely assumed the percent particulate amount in the
4 influent water stream, correct?

5 A. I see that written at the bottom of the page,
6 yes, sir.

7 Q. Okay. Let's review. Let's have RDX-16.14.

8 So here I have your demonstrative here with the
9 17 embodiments you say were made and tested with challenge
10 water, the '141 patent, correct?

11 A. Yes, sir.

12 Q. Okay. And for 15 of those 17, those were tested
13 assuming what the influent colloidal and soluble lead levels
14 were during testing, correct?

15 A. Yes, sir, after measuring it in each case at the
16 beginning of the experiment, and then using that challenge
17 water within 24 hours as per the NSF specification.

18 Q. Again, we have five filters here that went over
19 10 ppb during testing, and you had no problem ascribing them
20 a lifetime, correct?

21 A. Yes, before the Claim Construction Order came
22 out, that's correct.

23 Q. Okay. Let's review, Dr. Freeman. Back in May
24 2022, as one of ordinary skill in the art, and under all
25 constructions proposed by the parties, you calculated the

1 FRAP value for 35 different practicing filters, correct?

2 A. Yes, sir, that's correct.

3 Q. Okay. Can I have RDX-16.16, please?

4 As we've talked about, seven of those filters you
5 opined practice the '141 patent under all constructions,
6 including Brita's, at a FRAP of under 350 and you averaged
7 the flow rate for f using three sample points or less,
8 correct?

9 A. Yes, sir.

10 Q. Okay. And at least for 21 of those, the
11 reductions to practice and filters you say practice the
12 patent under the '141 patent had a lead effluent over 10
13 parts per billion, correct?

14 A. I didn't count them as we went along, but I'll
15 take your word for it.

16 Q. Okay. And because they went over 10 parts per
17 billion, Dr. Freeman, they couldn't be certified for NSF 53
18 2007, correct?

19 A. Yes. They would be above the limit for the NSF
20 53 standard, which is 10 parts per billion lead at the end
21 of the filter lifetime.

22 Q. Thank you, Dr. Freeman. And despite that, you
23 opined that those 21 or so filters practice the patent,
24 correct?

25 A. Yes, sir, that was correct, before we got the

1 Claim Construction Order.

2 Q. Okay. But you opined that under both parties'
3 constructions, correct?

4 A. Yes, sir, I considered both parties'
5 constructions.

6 Q. Including Brita's, correct?

7 A. Including Brita's and including Respondents',
8 yes, sir.

9 Q. Okay. And, lastly, we have 15 that we just
10 discussed filters where the influent colloidal lead was
11 assumed but not actually tested at the 3L and 76L and 151L
12 mark during testing, correct?

13 A. Yes, sir, there was a number of those that we
14 looked at where it appears that the colloidal lead was not
15 measured at all of the time points.

16 And, again, I've explained that the NSF standard
17 requires certain conditions to make the challenge water and
18 then says that it -- that it will be stable and can be used
19 for up to 24 hours, and I believe Brita followed that
20 procedure.

21 Q. Okay. And, again, it was okay in your opinion to
22 assume that the colloidal and soluble lead levels were met
23 within the claim 1 of the '141 patent, correct?

24 A. Yes, sir, based on the testing of the challenge
25 water at the beginning of the -- at the beginning of those

1 tests.

2 Q. Thank you, Dr. Freeman.

3 MR. SWAIN: Your Honor, may I step away from the
4 podium for one moment? There's a colleague from the
5 LifeStraw Respondents who may have some questions with
6 Dr. Freeman. May I step away for one minute to confer with
7 him?

8 JUDGE MCNAMARA: Yes.

9 MR. SWAIN: Thank you, Your Honor.

10 Your Honor, Mr. Jeff Gargano has a brief
11 cross-examination for Dr. Freeman as well. As he is making
12 his way to the podium, I do want to make a correction for
13 the record that, when I mentioned CX-109, I meant CX-108.
14 That's the lab notebook of Dr. Knipmeyer.

15 JUDGE MCNAMARA: Thank you.

16 Good afternoon, Mr. Gargano.

17 MR. GARGANO: Good afternoon, Your Honor.

18 CROSS-EXAMINATION

19 BY MR. GARGANO:

20 Q. Good afternoon, Dr. Freeman. Good to see you
21 again. I don't know if you remember, but my name is Jeff
22 Gargano. I represent LifeStraw Respondents in this case.

23 And I just want to ask you a few questions about
24 your testimony on direct examination that the asserted
25 claims of the '141 patent are entitled to a priority filing

1 date of October 29, 2007 based on the '372 application. Do
2 you recall that testimony?

3 A. Yes, sir.

4 Q. Okay. Mr. Campos, can we pull up JX-22, the '141
5 patent, the face of the patent, and can we highlight the
6 heading Related U.S. Application Data.

7 Okay. Dr. Freeman, do you see where it states
8 that the application that resulted in the '141 patent is a
9 continuation-in-part of Application No. 11/927,372. That's
10 the '372 application that you testified about, correct?

11 A. Yes, sir.

12 Q. Okay. And Dr. Freeman, you're familiar, you're
13 an inventor, and I think you said 24 or 25 issued patents,
14 are you familiar with the patent term
15 "continuation-in-part"?

16 A. Vaguely. I'm not a lawyer, so I don't know all
17 the ins and outs of it from a legal point of view.

18 Q. Okay. Can I just have your understanding of what
19 you think a continuation-in-part application is?

20 A. My understanding is that these are applications
21 from which the ultimate application that became the '141
22 patent was derived in whole or in part.

23 Q. Okay. And so you would agree with me, then, that
24 an application -- a continuation-in-part application means
25 that the application repeats some portion or all of an

1 earlier application and it also adds new matter, correct?

2 A. Yes, sir, that's my understanding.

3 Q. Okay. Now with that understanding in mind, let's
4 turn to RX-376, please.

5 Professor Freeman, this is the file history of
6 the '372 application, and I believe you testified that you
7 reviewed the '372 application file history and you relied on
8 it in forming your opinions in this case, correct?

9 A. Yes, sir.

10 Q. Okay. And the '372 application was filed on
11 October 29th, 2007, correct?

12 A. Yes, sir.

13 Q. Okay. And do you know, Dr. Freeman, whether a
14 patent ever actually issued from the '372 application?

15 A. My understanding was that it was ultimately
16 abandoned, I believe, in 2012.

17 Q. Okay. That's my understanding as well. And
18 we're going to take a look at that.

19 Can we have RX-376.239?

20 And Dr. Freeman, is this the Notice of
21 Abandonment from the '372 application?

22 A. Yes, it appears to be.

23 Q. Okay. And it says in this Notice of Abandonment
24 that the applicant's failure to timely file a proper
25 response to an Office Action that was mailed on April 16th,

1 2012, resulted in the abandonment of the '372 application,
2 correct?

3 A. Yes, sir, that's what it says.

4 Q. Okay. Let's turn to the next -- we're going to
5 actually move backwards in time in the file history.

6 So .228, please.

7 Professor Freeman, is this the April 16th, 2012
8 Office Action that is referenced in the Notice of
9 Abandonment?

10 A. Yes, sir. This is a -- this appears to be an
11 April 16th, 2012 office date for the '372 application, as
12 far as I can tell.

13 Q. Okay. Let's go to RX-376.229, please. And can
14 we highlight lines 1 and 2a under the heading Status and
15 highlight lines 5 and 7 under the heading Disposition of
16 Claims.

17 So in the April 16th, 2012 Office Action in the
18 '372 application, Dr. Freeman, the USPTO finally rejected
19 then pending claims 1 through 5, 7, and 20, correct?

20 A. Yes, sir, I see that.

21 Q. Okay. And the final rejection was in response to
22 an earlier communication that Brita had filed on March 12th
23 of 2012, correct?

24 A. Yes, sir, that appears to be the case.

25 Q. Okay. Let's go to the next page, RX-376.230,

1 please, Mr. Campos.

2 And this is the -- can you read, Dr. Freeman, the
3 second full paragraph that begins with claims 1-5, 7, and
4 20?

5 A. So it says 1 through 5, 7 and 20 are rejected
6 under 35 U.S.C. 112, first paragraph, as failing to comply
7 with the written description requirement. The claims
8 contains subject matter that was not described in the
9 specification in such a way as to reasonably convey to one
10 skilled in the relevant art that the inventors at the time
11 the application was filed had possession of the claimed
12 invention.

13 Q. Okay. And then can we go down to the fourth
14 paragraph here that starts with claims 1 through 5, 7, and
15 20, and can you read that into the record, please,
16 Dr. Freeman.

17 A. Claims 1-5, 7 and 20 are rejected under 35 U.S.C.
18 112, first paragraph, because the specification, while being
19 enabling for formulations PA 1-1, PA 1-2, PA 2-1, PA 2-2, PA
20 2-3, PT 2-1, and PT 2-3 given in Table 4 does not reasonably
21 provide enablement for all of the possible formulations
22 recited in claims 1 through 5.

23 Q. Okay. So the claims of the '372 application were
24 finally rejected based on both a lack of written description
25 and a lack of enablement through section 112, correct?

1 A. Yes, sir, that's correct.

2 Q. Okay. And Brita failed to respond to this, and
3 so the '372 application was ultimately abandoned, correct?

4 A. That appears to be the case, yes, sir, in 2012.

5 Q. Okay. I want to look at the March 12th, 2012
6 communication from Brita that led to this final rejection.

7 So can we pull up RX-376.214, please.

8 And do you see, Dr. Freeman, that this is the
9 response to the -- this is a response to a non-final Office
10 Action that was filed by the inventors in the '372
11 application?

12 A. Yes, sir, I do see that.

13 Q. Can we have the next page, RX-376.215, please.

14 And do you see in this response, Dr. Freeman, the
15 inventors are submitting amended claim 1?

16 A. Yes, I do see that.

17 Q. Okay. And so will you agree with me that this is
18 claim 1 of the '372 application that was subject to the
19 final rejection that we just looked at, correct?

20 A. Yes, sir, tracing back the way you've done, that
21 would appear to be the case.

22 Q. Now I'd like to compare the scope of this finally
23 rejected claim 1 of the '372 application and compare that
24 with the scope of claim 1 of the '141 patent. Are you with
25 me, Dr. Freeman?

1 A. Sure.

2 Q. Okay. And we have a demonstrative that puts both
3 claims on one slide.

4 Can we pull up RDX-16.19?

5 And on the left-hand side here we have the
6 excerpt from RX-376.215, which is claim 1 of the '372
7 application, Dr. Freeman, and on the right-hand side we have
8 claim 1 of the '141 patent.

9 And would you agree with me, Dr. Freeman, that
10 the scope of claim 1 of the '141 patent is much broader than
11 the scope of the finally rejected claim 1 in the '372
12 application?

13 A. I'm not sure that I would necessarily agree with
14 that, because we're comparing claims from an application
15 versus the accepted patent. They have some commonalities in
16 their specifications. They also have differences.

17 And so I think you need to take -- I'd need to
18 take these documents and look at them very closely before I
19 could come to that conclusion with you.

20 Q. Okay. Well, let me walk through the claim and
21 try to highlight some of the differences and see if we could
22 come to that conclusion.

23 So in claim 1 of the '372 application, do you see
24 that the claim in the preamble is limited to a gravity-fed
25 carbon block water filter? Do you see that?

1 A. Yes, sir.

2 Q. And you'll agree with me that claim 1 of the '141
3 patent is not limited to a carbon block water filter,
4 correct?

5 A. That's correct.

6 Q. Okay. And in claim 1 of the '372 application the
7 activated carbon particles are limited to 30 to 50 percent,
8 correct?

9 A. Yes, that's correct.

10 Q. And they are also limited in size to having a
11 mesh size of about 80 x 325. Do you see that?

12 A. Yes, sir.

13 Q. Okay. And there's no similar limitations on the
14 activated carbon in claim 1 of the '141 patent, correct?

15 A. There's no express limitation like the one that
16 you just pointed out.

17 Q. Well, is there an implied limitation on the size
18 or the amount of the activated carbon in claim 1 of the '141
19 patent?

20 A. Well, you would have to use activated carbon or
21 that ingredient of filter of the right amount, right size,
22 so that -- so that you met the FRAP limitation below, and
23 not just any activated carbon or any amount of activated
24 carbon would do that.

25 So, yes, there is -- there is a limitation on the

1 carbon there and the limitation comes about through the FRAP
2 factor.

3 Q. Okay. We'll come back to that. Let's continue
4 on through claim 1 of the '372 application.

5 JUDGE MCNAMARA: Mr. Gargano, pardon me, but
6 before we continue, it is now 5:20. So how much more time
7 do you estimate that you're going to take? And then we have
8 not started the redirect and recross yet. So how much more
9 time do you think you have?

10 MR. GARGANO: Understood, Your Honor. I think
11 that I probably have about 20 minutes total.

12 JUDGE MCNAMARA: Oh, Lordy. Okay.

13 Mr. Ainsworth, where are you on all this?

14 MR. AINSWORTH: Your Honor, I don't think I would
15 have very long redirect at all. But I do want to say, I'm
16 not sure how this is in the scope of our direct examination.
17 We didn't cover the claims of the '372 application. This is
18 really kind of going far afield that Dr. Freeman opined on
19 and testified to. So I'm concerned about where we're going
20 with this next 20 minutes.

21 MR. GARGANO: Your Honor --

22 JUDGE MCNAMARA: Mr. Gargano, go ahead.

23 MR. GARGANO: Yeah. I mean, Your Honor,
24 Dr. Freeman just opined that the '372 application provides
25 written description support for the claims of the '141

1 patent, and this will show that it doesn't provide support,
2 that the Patent Office rejected claims that were much more
3 narrow than even the claims in the '141 patent. And that's
4 what this examination is directed to show.

5 JUDGE MCNAMARA: That's what I had understood as
6 well, Mr. Ainsworth. You may not have exactly gone into
7 this file history, but there was comparison between the '372
8 patent application and the '141. So I don't think this is
9 beyond the scope. It's just going into different documents
10 that explain different content.

11 Okay. So we have 20 minutes. We have, what,
12 another 10 or 15 minutes from you, Mr. Ainsworth?

13 MR. AINSWORTH: Yeah, Your Honor, no more than 10
14 or 15.

15 JUDGE MCNAMARA: Okay. Mr. Swain, would you like
16 to weigh in on the amount of time you might need?

17 MR. SWAIN: Your Honor, hopefully you can hear
18 me, I don't think I will need anything -- my
19 cross-examination is done. And if Mr. Ainsworth really does
20 have a short redirect, I doubt I will have a recross.

21 And I will mention that we will not be calling
22 Gary Hatch in rebuttal to priority, so hopefully we can wrap
23 this up today.

24 JUDGE MCNAMARA: All right. So we'll still have
25 to enter exhibits into the record when we're done. Have

1 your teams at least talked to one another and agreed on
2 exhibits for submission?

3 MR. SWAIN: Yes, Your Honor. We just sent a list
4 over to Brita, and I think it's about half a dozen exhibits
5 tops, and it shouldn't be objectionable. We should be ready
6 to do that as soon as this examination concludes.

7 JUDGE MCNAMARA: Okay. Ms. Kinkade.

8 (Discussion regarding time estimation.)

9 JUDGE MCNAMARA: Let's take a five-minute break.
10 So I'll see you back here at 5:28.

11 (Whereupon, the proceedings recessed at 5:23
12 p.m.)

13 (In session at 5:28 p.m.)

14 JUDGE MCNAMARA: All right. Good afternoon,
15 everyone.

16 Mr. Gargano, if you would like to continue.

17 MR. GARGANO: Thank you very much, Your Honor.

18 Q. All right. Dr. Freeman, right before the break
19 we were walking through claim 1 of the '372 application.
20 You'll see that claim 1 of the '372 application also
21 requires a binder material and it requires an amount of
22 binder material, 35 to 40 percent, and a very specific type
23 of binder material, ultra high molecular weight
24 polyethylene. Do you see that?

25 A. Yes, I do see that.

1 Q. And you'll agree with me that claim 1 of the '141
2 patent does not limit the gravity-fed water filter to a
3 binder. It doesn't require a binder of any kind, correct?

4 A. It doesn't require a binder in the claims. If
5 you're making filters like the ones that are set forth in
6 the '141, it would be very typical to have a binder, and
7 there's a lot of discussion about that. But the word binder
8 doesn't appear in claim 1.

9 Q. Right. And that's the reason why claim 1 is
10 broad enough to cover a mixed-media filter, correct?
11 Typically a mixed-media filter doesn't have a binder,
12 correct?

13 A. That's correct.

14 Q. Okay. And so let's move along.

15 Do you see that the lead scavenger in claim 1 of
16 the '372 application is limited to a certain amount, 10 to
17 30 percent, and also to a very particular size, and that is
18 18 to 70 microns? Do you see that?

19 A. Yes, sir, I do see that.

20 Q. Okay. And claim 1 of the '141 patent does not
21 have similar limitations, correct? There is no limitation
22 on the amount of lead scavenger or the size of the lead
23 scavenger, correct?

24 A. There's no express limitation, although there is
25 an inherent limitation because of the -- because of the FRAP

1 value, you can't use just any lead scavenger in any amount
2 or in any size.

3 And so the FRAP value is constraining the lead
4 scavenger and ultimately would constrain the type and amount
5 of binder that you could put into a formulation and have it
6 work to give a FRAP value of less than 350.

7 Q. But you couldn't sit here and tell me what type
8 of lead scavenger, size or amount, one would use to achieve
9 a FRAP factor of, let's say, 300, correct?

10 A. One would -- one would start from the lead
11 scavengers that are in the working examples in the '141, and
12 then one could work backwards from the additional
13 information that's in the specification and I think get very
14 close to a FRAP value of 300, if that was -- if that was the
15 goal.

16 Q. And you would have to test that filter to
17 determine whether or not you actually achieved a FRAP factor
18 of 300 or not, correct?

19 A. Yes, sir. It was routine to test these filters.

20 Q. Okay. And do you also see that claim 1 of the
21 '372 application has an express limitation that the lead
22 concentration in the final liter of the effluent charge
23 water is less than 10 microns? Do you see that? I'm sorry.
24 Yes, 10 microns per liter after the 40 gallons of water.

25 A. Ten micrograms per liter or --

1 Q. Ten micrograms, yeah. 10 ppb, correct.

2 A. Yes, sir, I do see that.

3 Q. Okay. And is claim 1 of the '141 patent limited
4 to a final lead concentration of 10 ppb after the final
5 liter of effluent charge water?

6 A. So claim 1 doesn't have an explicit value of the
7 effluent lead concentration at the end of the lifetime, but
8 the patent is talking about meeting this new NSF standard
9 where the -- where the effluent concentration needs to be 10
10 ppb or less.

11 And so the way that enters in claim 1 is that the
12 lifetime will change if the lead concentration goes above 10
13 ppb, because if you're going to meet the NSF standard, then
14 your lifetime can only be as great as the -- as the lifetime
15 before which the lead concentration goes above 10 ppb.

16 So there is wound up in there the -- a limitation
17 on the effluent lead concentration if you're actually going
18 to meet the standard that the '141 patent is -- that's the
19 problem they're trying to solve is how to meet the standard
20 and maintain good flow characteristics.

21 Q. It's true you could have a lead concentration
22 value of above 10 ppb and still have a FRAP factor below 350
23 and still fall within the scope of claim 1 of the '141
24 patent, correct?

25 A. So if you have -- if you have a lead

1 concentration above 10 ppb and the FRAP value is 350 or
2 whatever it is, what that would mean is that the lifetime
3 you specified for that filter is too long. And so, you
4 know, you have to make some adjustment to that if you're
5 going to satisfy the NSF standard, which is what the '141
6 patent was trying to do.

7 Q. I understand that's what you would need to do to
8 satisfy the NSF standard. I'm asking would that come within
9 the scope of claim 1, if you had lead concentration values
10 of above 10 ppb and you still had a FRAP factor below 350,
11 that would come within the scope of claim 1 of the '141
12 patent, correct?

13 A. No, sir. The way the claim construction worked
14 out and everything, I think the objective and the idea that
15 the inventors were pursuing in the '141 patent was to be
16 able to satisfy this new lead reduction standard. They make
17 that pretty clear in the specification.

18 And so they're looking for effluent lead
19 concentrations that are less than 10 ppb at the end of the
20 lifetime of the filter. And if you don't have that, it
21 means that the lifetime is not what you thought it might be.

22 Q. Okay. And you would then have to adjust the
23 lifetime in your claim, correct?

24 A. Well, you'd have to adjust the lifetime of the
25 filter until you got the lead concentration below 10 ppb,

1 and then you'd have to recalculate the FRAP value and see if
2 it was less than 350 or not.

3 Q. And moving along, in claim 1 of the '372
4 application, it has a limitation directed to the average
5 flow rate of at least 0.1 liter per minute through the
6 filter with a head pressure of between approximately 0.1 and
7 1 PSI. Do you see that?

8 A. Yes, sir, I do see that.

9 Q. And there's no corresponding limitation like that
10 on the average flow rate in claim 1 of the '141 patent, is
11 there.

12 A. There's not -- there's not -- those words don't
13 appear in claim 1, but claim 1 is also directed towards a
14 gravity-fed water filter, and a person of ordinary skill in
15 the art would know from reading the specification that in
16 those applications it's typical to filter with a head
17 pressure between .1 and 1 psi. And when you do that, then
18 you'll get a certain flow rate. And if that flow rate
19 coupled with the volume C_e and L such that it meets the FRAP
20 limitation, then that -- then that filter would fall within
21 the boundaries of claim 1.

22 Q. So your answer is it depends.

23 A. My answer is that because of the
24 interrelationship between the variables of the volume of the
25 filter media, the flow rate, the effluent lead concentration

1 and the filter lifetime, because these depend sensitively on
2 the materials that are used in the filter and on the way
3 that filter is made and its geometry and so forth, that you
4 could get to the limits that you're talking about in this
5 claim in the '372, but you'd have to -- you do that by
6 recognizing the interdependence of these variables. It's
7 not like you can just have any flow rate you want and
8 satisfy -- satisfy claim 1 of the '141 patent.

9 Q. You can't tell me what the limitation is on the
10 flow rate for claim 1 of the '141 patent, correct? You
11 would have to test it and see how that impacted the other
12 variables of FRAP, for example, the volume and the effluent
13 lead concentration, correct? That's that whole
14 interdependent relationship between the FRAP variables,
15 correct?

16 A. Yes, sir, that's correct, and a person of skill
17 in the art would know how to do that.

18 Q. Now claim 1 also requires -- of the '372
19 application -- also requires limitations to the block wall
20 thickness and to the density of the block, correct?

21 A. Yes, sir, I see that at the bottom of the page.

22 Q. Okay. And there are no similar limitations in
23 claim 1 of the '141 patent, correct?

24 A. Those don't -- that particular language doesn't
25 appear. There are limitations because the wall thickness of

1 the block is going to affect the volume of the filter media
2 and it's going to affect the flow rate and potentially also
3 then the effluent lead concentration at the end of lifetime
4 and the usage lifetime, and the density of the block will
5 certainly affect the flow rate of water through the block.
6 And so there are limitations on what those values can be
7 that would be based on the practical filter that you made
8 and tested.

9 Q. Okay. Now the October 29, 2007 filing date of
10 the '372 application, that was approximately 17 months after
11 the alleged conception date of May 16th, 2006, correct?

12 A. In round numbers, yes, sir.

13 Q. Okay. And the filing date of the '372
14 application is also more than one year after you allege the
15 inventors actually reduced to practice these different
16 embodiments in June and July of 2006, correct?

17 A. Yes, sir.

18 Q. Okay. And, in fact, the '372 application was
19 filed more than one year after Dr. Knipmeyer first
20 articulated and wrote in the document -- I think it's
21 CX-139C that you testified to on your direct examination --
22 it was one year after Dr. Knipmeyer articulated FRAP and
23 also put together the graphs that wound up in the '141
24 patent application, correct?

25 A. Yes, sir.

1 Q. Okay. And yet the FRAP factor is not disclosed
2 explicitly in the '372 application, correct?

3 A. That's correct. It is there inherently, as I've
4 testified to today.

5 Q. The FRAP formula is not disclosed in the '372
6 application, correct?

7 A. Yes, sir, that's correct.

8 Q. And, in fact, the specific relationship between
9 the filter variables, volume, lifetime, average flow rate,
10 and effluent lead concentration, as defined in the FRAP
11 formula in the '141 patent, is not disclosed in the '372
12 application, correct?

13 A. Could I have the question back again? I
14 apologize.

15 Q. Sure. The specific relationship between the
16 filter variables, volume, lifetime, average flow rate, lead
17 effluent concentration, as defined in the FRAP formula of
18 the '141 patent, is not disclosed in the '372 application,
19 correct?

20 A. So the FRAP formula itself is not -- is not
21 explicitly disclosed in the '372 application. I believe it
22 is inherently disclosed, and there is language that we
23 looked at earlier today about placing a limitation on the
24 specific performance of the filter based upon the four
25 variables that constitute the FRAP equation.

1 Q. Dr. Freeman, you could not calculate FRAP values
2 for the embodiments in the '372 application without making
3 reference to the '141 patent, correct?

4 A. We could calculate -- I could calculate FRAP
5 values based on what's in the '141 patent and also in the
6 documents that we looked at from Brita.

7 Q. Right, but a person of ordinary skill in the art
8 would not have access to the Brita documents and would not
9 have access to what was in the '141 patent when it was
10 filed, correct?

11 A. That's correct. A person of ordinary skill in
12 the art would have access to the examples that were in the
13 '372 and they would understand the interplay between these
14 variables and be able to design and invent a filter based on
15 that.

16 Q. You told me, Dr. Freeman, in your deposition that
17 FRAP was not within the sphere of public knowledge prior to
18 the filing date of the '141 patent, correct?

19 A. You'll have to remind me of that.

20 Q. Okay. One of ordinary skill in the art would not
21 have knowledge of the FRAP formula prior to the filing of
22 the '141 patent, correct?

23 A. In my opinion that would be the first time that
24 it was -- that it was articulated as a mathematical
25 formulation in a patent application. A person of ordinary

1 skill in the art would have realized from the '372 and the
2 examples and the information in there of the strong
3 interdependence between the four variables that constitute
4 the FRAP equation and the fact that those variables'
5 interdependence gives rise to specific performance criteria
6 that are used to judge the performance of these filters, and
7 that would be what a person of ordinary skill in the art
8 would use to make filters that were within -- that were
9 within the claim scope.

10 Q. A person of ordinary skill in the art wouldn't
11 have access to that FRAP formula, correct, at the time of --
12 prior to the filing of the '141 patent, correct?

13 A. As far as I know, the FRAP formula first appeared
14 in the '141 patent.

15 Q. Okay. So the answer to the question is no, they
16 would not have knowledge of the FRAP formula prior to the
17 filing of the '141 patent, correct?

18 A. They would not know the mathematical formula in
19 the form in which it's written in the '141 patent. They
20 would understand, however, the interrelationship between the
21 variables that go into the FRAP factor and be able to
22 understand how they traded off against one another and how
23 to make filters that were inventive based upon varying those
24 values, and they would also understand based on the prior
25 art filter work what values of those performance criteria

1 and physical characteristics were outside the range of the
2 inventive filters.

3 Q. There's no mention in the '372 application that
4 you multiply the volume of the filter media times the flow
5 rate times the lead effluent concentration to come up with a
6 FRAP numerator, correct?

7 A. Yes, sir, that's correct. There's no mention of
8 the FRAP equation, and so then there's no mention of the
9 numerator that you just elaborated.

10 Q. And there's no mention of the denominator either,
11 is there, in the '372 application.

12 A. Not explicitly, no, sir.

13 Q. Okay. And there's no mention of multiplying the
14 lifetime of the filter by 2, right? That's nowhere in the
15 '372 application, correct?

16 A. No, sir, it's not.

17 Q. Okay. And there's no disclosure in the '372
18 application of a FRAP factor range of 0 to 350, is there.

19 A. There's no explicit, because the FRAP equation is
20 not there and FRAP values were not calculated explicitly in
21 the '372. You won't find those numbers or that numerical
22 range.

23 However, in my opinion, those variables are
24 inherently present based on the values for the working
25 examples, and a person of skill in the art would know how to

1 use that information to derive the inventive filters, which
2 would have FRAP values less than 350.

3 Q. I'm sorry. I didn't mean to speak over you,
4 Dr. Freeman.

5 There's no disclosure in the '372 application
6 that range of 0 to 200 for FRAP is even a more preferred
7 range than 0 to 350, is there?

8 A. There's no mention of FRAP values in the '372
9 application. However, a person of ordinary skill in the art
10 would know that, if you manipulated the four variables that
11 give -- that give rise to the ultimate performance of the
12 filter in such a way that they move the FRAP value to a
13 lower value, that that would be a preferred filter.

14 Q. The inventors never appreciated that the
15 embodiments in the '372 application actually had FRAP values
16 like the values that you had in your demonstrative, correct?

17 A. I don't -- I don't recall testimony about that.
18 Certainly those FRAP values were not reported in the '372
19 application.

20 Q. And you have no evidence and you've presented
21 none, either in your expert report or your direct
22 examination, that the inventors actually calculated FRAP of
23 the filters in the '372 application, correct?

24 A. I don't recall -- they calculated FRAP values for
25 many of their filter formulations. I've seen the underlying

1 data for that. I don't recall specifically for those
2 particular filters in the '372, if I've seen their internal
3 calculations or not. I've looked at a lot of FRAP values
4 and a lot of data.

5 Q. Sir, the FRAP values that were on your slides in
6 your direct examination, were those values that you
7 calculated based on information found in the inventor's lab
8 notebook?

9 A. That was information in the '372 application. It
10 was information that I found in the -- I believe it was
11 Table 13 of the '372, plus the correction notice that was
12 filed that corrected the volume.

13 Q. But that wasn't a FRAP calculation that you found
14 that someone else had actually calculated, correct?

15 A. I calculated those myself. I know that the
16 inventors had also calculated a lot of FRAP values, and I
17 don't recall right now if there was overlap between the ones
18 that I calculated and the ones that appeared in some of
19 their calculations.

20 Q. As you sit here today, Dr. Freeman, you can't
21 tell us whether or not the inventors actually appreciated
22 that the filters in the '372 application achieved a FRAP
23 factor below 350, correct?

24 A. I believe that the inventors of the '372
25 application appreciated that those filters had superior lead

1 removal and fast flow rate, and that they further codified
2 that in the FRAP formula when the '141 patent was filed.

3 And so I think the inventors -- the inventors
4 appreciated as early as sometime in the summer of 2006 of
5 how the FRAP calculation worked and how that could be used
6 to help guide them towards better filters and assess when a
7 filter was performing well.

8 Q. Okay. Dr. Freeman, that was not my question. My
9 question is very simple. You have no evidence to show that
10 the inventors appreciated that the filters disclosed in the
11 '372 application actually achieved a FRAP factor below 350,
12 correct? It's a yes or no answer.

13 A. Well, I think the inventors did appreciate that
14 the -- that they had made inventive filters and they would
15 later further codify that with their FRAP calculation in the
16 '141 and they have been working with the FRAP concept before
17 that.

18 And so I think they did appreciate that they had
19 inventive filters, and then ultimately expressed that in
20 terms of these FRAP factor ranges.

21 Q. But they didn't express that in the '372
22 application, correct?

23 A. The FRAP equation does not appear in the '372
24 application, that's correct.

25 Q. And there's no FRAP calculations for any of the

1 filter embodiments in the '372 application, correct?

2 A. Well, I've made FRAP calculations.

3 Q. I understand that, but you made those FRAP
4 calculations in May of 2022 in your expert report, correct?

5 A. A little before that.

6 Q. Okay. I'm asking you, there are no FRAP
7 calculations for any of the filters disclosed in the '372
8 application actually disclosed in the '372 application.

9 A. I've seen that the inventors were using FRAP in a
10 number of their internal spreadsheets, and I just don't
11 recall if -- if any of the ones that were in the '372, if
12 those had shown up in some of their earlier FRAP
13 calculations or not. I can't recall that right here.

14 Q. Okay. Can we pull up JX-22, please, Mr. Campos?
15 And let's go to column 5, lines 34 through 53.

16 Now this specific disclosure from column 5, lines
17 34-53 of the '141 patent, this is not disclosed in the '372
18 application, correct?

19 A. That's correct. This particular passage does not
20 appear verbatim in the '372 applications, yes, sir, you're
21 correct.

22 Q. So this disclosure is new matter in the CIP
23 application that resulted in the '141 patent, correct?

24 MR. AINSWORTH: Objection, Your Honor. That
25 calls for legal conclusion, what's new matter or not, I

1 don't think that's an appropriate question for an expert
2 witness. He is not a patent lawyer.

3 JUDGE MCNAMARA: I think there are other ways to
4 phrase that, Mr. Gargano, so that you can get around that
5 objection.

6 MR. GARGANO: Okay. Thank you, Your Honor.

7 Q. This disclosure we established is not in the '372
8 application, correct?

9 A. These words are not in the '372 application, as
10 you've shown them here, not all together like this, and the
11 FRAP, as we've talked about, the FRAP definition and means
12 of calculating that is not explicitly in the '372
13 application.

14 Q. Okay. And the FRAP formula, I don't know,
15 between lines 40 and 45, that's not in the '372 application,
16 correct?

17 A. The formula is not in the '372 application,
18 that's correct.

19 Q. Okay. Let's turn to column 6, lines 46 through
20 52 of the '141 patent. Let's blow that up.

21 You'll agree with me, Dr. Freeman, that this
22 disclosure of FRAP in the '141 patent is not in the '372
23 application, correct?

24 A. These words, the express disclosure like this is
25 not in the '372 application, that's correct.

1 Q. And there's no disclosure of a FRAP factor of
2 about 350 or less according to any formula in the '372
3 application, correct?

4 A. There's no FRAP formula in the '372 application.
5 I believe that it is, the FRAP values and limits are
6 inherently there, as we've discussed earlier.

7 Q. Okay. Let's turn to Fig. 21 of the '141 patent.
8 Dr. Freeman, Fig. 21 in the '141 patent is not
9 disclosed in the '372 application either, correct?

10 A. I don't believe that figure appears in the '372
11 application.

12 Q. And so the teaching of a FRAP factor as a
13 function of filter unit time and filter volume as disclosed
14 in Fig. 21 is not in the '372 application, correct?

15 A. This graph is not in the '372 application. The
16 teaching of the interrelationship of these variables is
17 taught in the '372 application. You see it in several
18 places throughout the specification.

19 Q. Where in the '372 application does it disclose
20 hypothetical volumes of 100, 150, and 200?

21 A. I don't --

22 Q. That's not in the '372 application, is it. I'm
23 sorry. That's not in the '372 application, is it.

24 A. I don't recall those words exactly in the '372
25 application, but it does discuss the range of volumes.

1 Q. Okay. And would you agree with me that Fig. 22
2 and Fig. 23, the other graphs in the '141 patent that you
3 testified to on direct examination, these are also not in
4 the '372 application, correct?

5 A. Yes, sir, that's correct.

6 MR. GARGANO: I have no further questions, Your
7 Honor.

8 JUDGE MCNAMARA: All right. Thank you.

9 Mr. Ainsworth, do you have any follow-up?

10 MR. AINSWORTH: Your Honor, just give me one
11 minute to confer.

12 JUDGE MCNAMARA: Sure. I think I should have
13 asked before I get back to Mr. Ainsworth, Mr. Gargano,
14 there's one other Respondent whose counsel hasn't asked
15 questions. Are the Respondents finished with their
16 cross-examination?

17 MR. GARGANO: We are finished, Your Honor. No
18 further questions on Dr. Freeman's direct exam, correct.

19 JUDGE MCNAMARA: Okay. Thank you.

20 MR. AINSWORTH: Your Honor, I think I have about
21 five minutes.

22 JUDGE MCNAMARA: Sure.

23 MR. AINSWORTH: I would say three questions but
24 it's never three questions.

25 JUDGE MCNAMARA: I know.

1 REDIRECT EXAMINATION

2 BY MR. AINSWORTH:

3 Q. Dr. Freeman --

4 JUDGE MCNAMARA: Believe me I know.

5 MR. AINSWORTH: I'm going to be very brief here,
6 Your Honor.

7 Q. Dr. Freeman, you were asked earlier about some
8 testimony from your deposition by Mr. Swain. Do you recall
9 generally some questions about answers you gave at your
10 deposition?

11 A. Yes.

12 Q. If you could please bring up Dr. Freeman's
13 deposition at pages 64, 65.

14 I want to paraphrase. I believe you said to
15 Mr. Swain that he was mischaracterizing or misconstruing
16 your testimony at pages 64 to 65.

17 Could you explain to Her Honor why you believe
18 your testimony was being misconstrued? And the question
19 begins at line 19 and goes -- on page 64, and goes until
20 your answer ends on line 11 on page 65.

21 A. Yes. And so what I think was being
22 mischaracterized here, Mr. Swain likes this
23 needles-in-a-haystack analogy, and I believe he is
24 understanding that I mean the haystack is inside the
25 boundaries of the '141 patent and you have to pick the

1 needles out of it, and that's simply not correct.

2 What I have said here is that there's an enormous
3 amount of background information and performance about prior
4 mixed-media. This is in the prior art that a person of
5 skill in the art would be aware of. And that is the
6 haystack from which someone wanting to use the '141 patent
7 could choose from to get the pieces that they need to make
8 the inventive filters, that is, the '141 patent is only an
9 incredibly small subset of what was known about mixed-media
10 filters.

11 Q. Thank you. We can take that down.

12 Now you were also asked about the amount of time
13 that it took Brita to develop its Longlast filter. I
14 believe counsel said it was about seven thousand hours. Do
15 you recall that line of questions?

16 A. I do.

17 Q. So is there a difference from developing an
18 embodiment or prototype of a water filter and developing a
19 commercially ready-to-manufacture water filter?

20 A. Absolutely.

21 Q. What are some of the differences?

22 A. Well, the differences are that, when you're
23 developing the prototype, you might have a small sample that
24 you make in a laboratory and test and you get unusual
25 positive results. Going from that to a fully scaled-up

1 manufactured product that can be made reliably at large
2 scale and can be distributed and marketed and sold is an
3 enormous undertaking.

4 And I have experience with this. I have
5 commercial products that are in the market. And in each of
6 those cases it took about ten years from the time of the
7 initial discovery until the product is actually in the
8 market being practiced, because there's a lot of steps
9 beyond the initial discovery phase where you have the "aha
10 moment," this is really different from everything else that
11 is out there.

12 That process typically occurs really quickly,
13 when you're working your way through a given problem. But
14 it's the rest of it in taking that initial finding and
15 scaling it up and making sure that you can make it at large
16 scale and make it reliably, and that you do the market
17 studies to understand what -- that there's a market for it
18 and what that market is and how to market it is an
19 enormously -- can be an enormous process. And that's very
20 different from the discovery or the inventive process, which
21 can be very, very fast.

22 Q. Or else in the prototyping process?

23 A. Yes, absolutely.

24 Q. Could you bring up -- there was a demonstrative
25 shown during the cross-examination that was RDX-16 at slide

1 19. This was during Mr. Gargano's questioning.

2 Now, Dr. Freeman, you were asked a bunch of
3 questions about the claims that were under prosecution of
4 the '372 application. Do you recall that?

5 A. I do.

6 Q. Are you a patent lawyer?

7 A. No, I'm not, thankfully.

8 Q. You are an inventor, though. Were you tasked at
9 all in this investigation with evaluating whether the claim,
10 claim 1 of the '372 application, shown on this slide,
11 whether that claim itself had written description support in
12 the '372 application?

13 A. No, sir, I wasn't.

14 Q. And do you understand that written description
15 and enablement support had to be shown on a claim-by-claim
16 basis for independent claims and dependent claims?

17 A. For the application at issue, absolutely.

18 Q. Thank you.

19 MR. AINSWORTH: Dr. Freeman, we have no further
20 questions.

21 JUDGE MCNAMARA: Okay. Thank you, Mr. Ainsworth.

22 Mr. Swain, any recross-examination?

23 MR. SWAIN: I'm happy to say, no, Your Honor, no
24 recross for Dr. Freeman. I think the issues are pretty well
25 briefed today, and we thank you for your time.

1 JUDGE MCNAMARA: Let me just double-check with
2 Mr. Gargano to be sure since he was asking questions before.

3 Mr. Gargano, do you have any additional
4 recross-examination?

5 MR. GARGANO: No further examination, Your Honor.
6 Thank you.

7 JUDGE MCNAMARA: All right. Very good. I just
8 needed to get that on the record so it was clear.

9 Okay. So with that, then, thank you,
10 Dr. Freeman, you may step down and leave, actually, or go
11 back home, if that's what you're doing.

12 THE WITNESS: Thank you, Your Honor. I'd like to
13 thank you and your staff and all the folks who have worked
14 late today to make this happen. I know people have families
15 and other obligations, and I appreciate them sticking with
16 us. And it was a pleasure to be here with you today.

17 JUDGE MCNAMARA: Thank you very much. Take care
18 going home.

19 THE WITNESS: Thank you.

20 JUDGE MCNAMARA: We still have exhibits to deal
21 with. Let me just also remind you, please, that I would
22 like to have the deposition, those parts of the deposition
23 and the expert reports also marked and the areas around them
24 so that I can make sure that the full import of the
25 testimony has been given.

1 MR. SWAIN: Certainly, Your Honor. We have given
2 our list of exhibits for admission to Brita and we haven't
3 heard any objections from them yet. They have had them for
4 about two hours by now. I'm sure Mr. Ainsworth is checking.

5 In the meantime, I did want to ask if it's okay
6 if Respondents file their motions to strike Dr. Freeman's
7 testimony this Monday. Would that be acceptable,
8 Your Honor?

9 JUDGE MCNAMARA: Yes.

10 MR. SWAIN: Thank you, Your Honor.

11 JUDGE MCNAMARA: And then if that's the case, the
12 responses will have --

13 Mr. Ainsworth, you'll have an equal amount of
14 time to respond. Since we're putting this off until Monday,
15 it's giving, essentially, two full business days plus the
16 weekend. So I'm going to give you four days as well so that
17 you can respond. I wouldn't get to them anyway because I'm
18 pretty busy right now. All right. Yeah, that's what we can
19 do.

20 So, Mr. Ainsworth, have you looked at the list of
21 exhibits?

22 MR. AINSWORTH: Yes, Your Honor, and I think we
23 do have an agreement. Why don't I just read them in, and,
24 Mr. Swain, if you disagree, let me know.

25 So the parties have agreed to admission of

1 CX-962, as well as RDX-8, which is the Hatch demonstratives,
2 CX-343, CX-347, CX-836, CX-842, CX-843, CDX-2, which are the
3 Freeman demonstratives, RDX-16, the Freeman cross
4 demonstratives that were shown to Dr. Freeman, excerpts from
5 the Freeman report at RX-878, RX-376, which is the '372
6 application. And I think we're in agreement on submitting
7 the portions of the deposition pages that were shown. We
8 haven't exchanged those yet, but I don't think we'll have a
9 problem of working that out, so we'll submit those pages as
10 well.

11 (Complainant Exhibit Numbers CX-962, CX-343,
12 CX-347, CX-836, CX-842, CX-843, CDX-2 were received into
13 evidence.)

14 (Respondents Exhibit Numbers RDX-8, RDX-16,
15 RX-878, RX-376 were received into evidence.)

16 JUDGE MCNAMARA: I think that's agreeable.

17 Mr. Swain, does that comport, and does the
18 reading of the exhibits and the identified exhibits comport
19 with your understanding of the agreement and the agreed-upon
20 exhibits?

21 MR. SWAIN: Yes, Your Honor, I'm happy to say
22 Mr. Ainsworth and I agree on this, so I think we're all set.

23 JUDGE MCNAMARA: Very good. The other thing I
24 wanted to mention is that each of your teams has identified
25 someone to receive a Box link from Ms. Muhammad. So they

1 may have already received the Box link, but I'm pretty sure
2 she is gone for the day. If they have not, I'm sure she
3 will submit a Box link to them tomorrow to make sure that
4 all the exhibits from today are loaded into the Box link.
5 We do not accept FTP or other forms at this point. So it's
6 just the Box.

7 Is there anything else that I need to address
8 other than the fact that, as I think about it, on August
9 23rd I gave you the dates, and then we issued an order on
10 the dates for briefing this part of the hearing. Take a
11 look at the August 23 transcript. We gave you additional
12 dates briefing time to take care of today's testimony. And
13 there's an order.

14 MR. AINSWORTH: And there is an order,
15 Your Honor, yes.

16 JUDGE MCNAMARA: And it was the last day of the
17 hearing. It's at, like, 3:30 on August 23, I gave you some
18 oral orders, which included acting on your oral motions to
19 extend the briefing schedules. Okay.

20 Is there anything else that you need or anything
21 else I need to address before we conclude?

22 MR. SWAIN: Not from Respondents, Your Honor.
23 Again, I just wanted to thank everyone for their time,
24 including Ms. Kinkade, as usual, for staying late and,
25 again, just a fantastic job by everyone. So thank you all.

1 And I'm sorry for talking over you, Ms. Kinkade.

2 (Discussion to clarify the entry of exhibits.)

3 JUDGE MCNAMARA: Anything more, Mr. Ainsworth?

4 MR. AINSWORTH: Your Honor, just on behalf of
5 Brita and our team, we want to thank you and the staff for
6 everything you've done, for going late tonight and putting
7 up with all of our challenges. So thank you, Your Honor.

8 JUDGE MCNAMARA: Well, it helps to create a more
9 complete record, as you know.

10 And thank you. Take care everybody. And thank
11 you for a good trial. Have a good evening.

12 //

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14 (Whereupon, the evidentiary hearing concluded at
15 6:11 p.m.)

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3 WATER FILTERS AND PRODUCTS CONTAINING THE SAME

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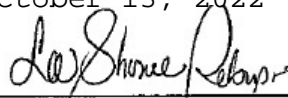
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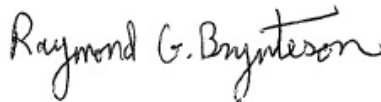


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NSF/ANSI 53 – 2007

Drinking water treatment units — Health effects

**NSF International Standard/
American National Standard**

NSF/ANSI 53 – 2007



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for Drinking Water Treatment Units —
Drinking water treatment units –
Health effects**

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Foreword²

The purpose of this Standard is to establish minimum requirements for materials, design and construction, and performance of drinking water treatment systems that are designed to reduce specific health-related contaminants in public or private water supplies. NSF/ANSI 53 specifies minimum product literature requirements that manufacturers must provide to authorized representatives and owners.

Water contact materials in drinking water treatment units listed under NSF/ANSI 42, 44, 53, 55, 58, and 62 are tested and evaluated under a separate protocol from NSF/ANSI 61 with criteria that were developed specifically for the intended end use. NSF/ANSI 61 listing should not be additionally required for acceptance of these listed units for water contact application.

This edition of the Standard contains the following revisions:

- Updates to tables 7, 8, 11, 13, and 14 clarifying the requirements for influent challenge requirements for chemical reduction testing.
- A test method that includes the ability to generate and measure particulate lead, added to 7.4.3.

This Standard was developed by the NSF Joint Committee on Drinking Water Treatment Units using the consensus process described by the American National Standards Institute.

Suggestions for improvement of this Standard are welcome. Comments should be sent to Chair, Joint Committee on Drinking Water Treatment Units, c/o NSF International, Standards Department, P. O. Box 130140, Ann Arbor, Michigan 48113-0140, USA.

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Exhibit 2

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Fabrication of blend biodegradable nanofibrous nonwoven mats via multi-jet electrospinning

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Abstract

A series of blend biodegradable nanofibrous mats comprising poly(vinyl alcohol) (PVA) and cellulose acetate (CA) were prepared via multi-jet electrospinning. A relative high voltage (20 kV) was used to supply the power for multi-jet electrospinning. The weight ratio of PVA/CA in blend nanofibrous mats can be controlled by changing the number ratio of jets of PVA/CA. Moreover, the real composition of PVA and CA in blend nanofibrous mats was determined by immersing the blend nanofibrous mats into water to remove the PVA component. Morphology, dispersibility, and mechanical properties of blend nanofibrous mats were examined by field emission scanning electron microscopy (FE-SEM), Fourier transform infrared (FT-IR) spectroscopy, wide-angle X-ray diffraction (WAXD), and tensile test. The results showed that the blend nanofibrous mats have good dispersibility. Additionally, the mechanical properties of blend nanofibrous mats were largely influenced by the weight ratio of PVA/CA in blends. Potential applications of the blend nanofibrous mats include filters and biomedical materials.

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Keywords: Multi-jet electrospinning; Blend nanofibrous mats; Dispersibility

1. Introduction

In past decades, electrospinning technique has attracted great attention because polymer nanofibers with high surface-to-volume ratio can be fabricated by using this technique [1–5]. Polymer nanofibers have a broad range of applications such as tissue engineering [6], sensor [7], protective clothing [8], filter [9], etc. A number of processing techniques are combined with electrospinning to get functional nanofibrous mats such as electrospinning the mixture of polymer with sol–gel solution [10,11], the mixture of blends of polymers in the same solvent [12,13], the mixture of single polymer in co-solvent [14], and the mixture of polymer solution with nanomaterials [15–17]. Additionally, a novel method was reported by Sun et al. to fabricate the compound core/shell polymer nanofibers by co-electrospinning [18].

Recently, Gupta et al. [19] prepared blend nanofibers of bicomponent system by using a side-by-side electrospinning fashion under fixed state. We sought to increase the dispersibility of multi-component in the blend nanofibrous mats in order to get uniform properties of blend nanofibrous mats. Hence, we designed a multi-jet electrospinning device to afford the opportunity for electrospinning not only bicomponent but also multi-component. Meanwhile, the movable multi-jet and rotatable grounded tubular layer is adopted to get the uniform thickness of blend nanofibrous mats with good dispersibility of multi-component. This approach can be used to fabricate blend nanofibrous mats with multi-component polymers which cannot be dissolved in the same solvent or kept in the same container (polyanion and polycation).

Poly(vinyl alcohol) (PVA), a water-soluble polyhydroxy polymer, has excellent chemical resistance, physical properties, and complete biodegradability which led to broad practical applications. PVA nanofibrous mats are already prepared by electrospinning the aqueous PVA solution and crosslinked with chemical crosslinking agent [20]. Cellulose acetate (CA) is a particularly useful polymer to prepare

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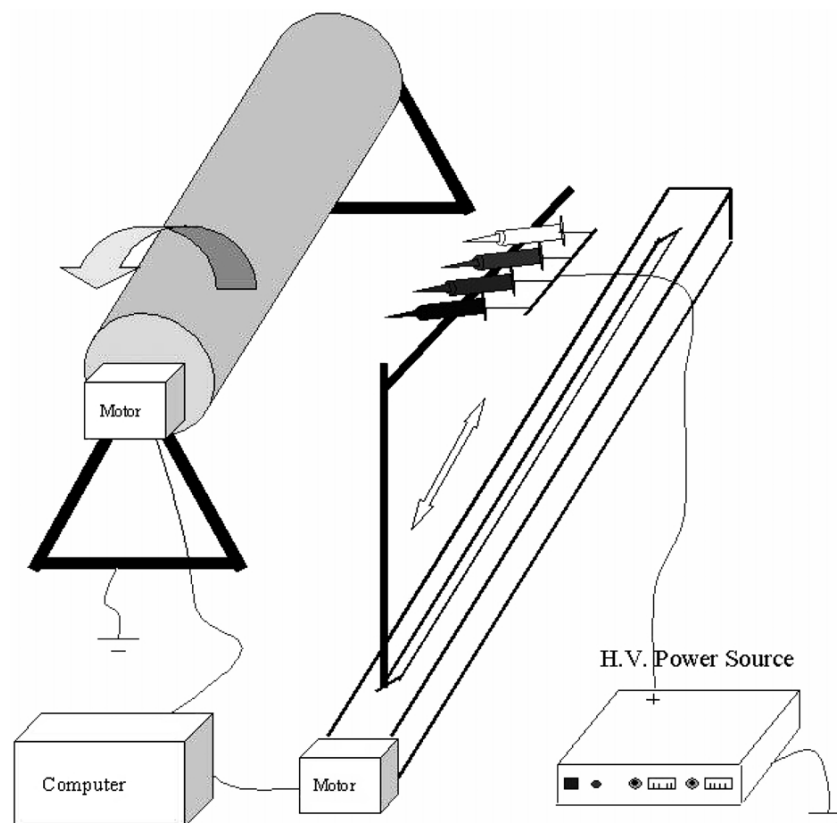


Fig. 1. Schematic of the electrospinning process.

hybrid materials because it can be easily molded into different forms such as membranes, fibers and spheres. The performance of CA may be improved by blending it with appropriate polymers in view of the fact that polymer blends have provided an efficient way to fulfil new requirements for material properties [21]. Preparation and morphology study of CA nanofibrous mats are reported by Liu and Hsieh [14]. Additionally, PVA and CA are both biodegradable polymers, which have no pollution to environment. Therefore, the new nanofibrous materials based on PVA and CA are expected to have both advantages of PVA and CA.

However, the blend nanofibrous mats of PVA and CA have not been reported because it is difficult to find a good solvent for preparing the blend solution of PVA and CA. In the current work, we try to fabricate a series of blend nanofibrous nonwoven mats of PVA and CA with multi-jet electrospinning method and study their morphology, dispersibility, and mechanical properties.

2. Experimental

2.1. Preparation and properties of polymer solution

A 10 wt% PVA (M_n 66,000) (Wako Pure Chemical

Industries, Ltd., Japan) solution was prepared from PVA powder and distilled water at 80 °C with vigorous stirring. CA (M_n 40,000) (Teijin Co. Ltd., Japan) solution was produced in acetone and *N,N*-dimethylacetamide (DMAc), the weight ratio of acetone to DMAc was 2:1. The concentration of CA solution tested was 10 wt%.

The viscosity and conductivity of PVA and CA solutions were measured by a viscotester (6L/R, Hakke, USA) and electric conductivity meter (CM-40G, TOA DKK Co., Japan), respectively.

2.2. Generation of blend nanofibrous mats

The schematic of the electrospinning process was shown in Fig. 1. A grounded stainless tubular layer was covered by a piece of aluminum foil and rotated [22] at 100 rpm. A multi-jet containing four plastic syringes (5 ml) were clamped to a stand which can be moved with the speed of 20 m/min along the track. The distance between two tips was 3 cm. The velocity of the rotatable tubular layer and the movable stand can be controlled by computer. The PVA and CA solutions were placed in different syringes according to the requirement. The positive electrode of a high voltage power supply (FC30P4, Glassman High Voltage Inc., USA) was connected with copper wires, which immersed in

Table 1
Properties of PVA and CA solutions

Sample	Concentration (wt%)	Viscosity (centipoises)	Conductivity (ms/m)	Throughput (mg/min jet)
PVA solution	10	420	18.6	1.9
CA solution	10	360	0.3	2.3

polymer solutions. The voltage was 20 kV, and tip-to-collector distance (TCD) was 15 cm. The number ratio of jets of PVA/CA was controlled with 4/0, 3/1, 2/2 and 0/4 to get blend nanofibrous mats with different weight ratio of PVA/CA. The homogenous nanofibrous nonwoven mats were collected on the surface of aluminum foil and dried at 80 °C in vacuum for 24 h.

2.3. Determination of composition of PVA and CA in blend nanofibrous mats

The composition of PVA and CA in blend nanofibrous mats was investigated by immersing the dried blend nanofibrous mats into distilled water to remove the PVA component. The immersion time was 48 h. Then, the wet nanofibrous mats were dried at 80 °C in vacuum for 24 h. The content of PVA was calculated with the weight loss during immersion. Each sample for immersion test was checked 10 times.

2.4. Characterization techniques

The morphology and diameter of nanofibrous mats were determined with field emission scanning electron microscopy (FE-SEM) (S-4700, Hitachi Ltd., Japan). The diameters of nanofibers were measured by using image analyzer (Adobe Photoshop 7.0). FT-IR spectra were recorded using a BIO-RAD FTS-60A/896 FT-IR spectrometer in the range 4000–400 cm^{-1} . The measurement of the crystallinity was carried out at room temperature with a wide-angle X-ray diffractometer (RTP300, Rigaku Co., Japan). The diffraction scans were collected at $2\theta = 5 - 40^\circ$ with the speed of $1^\circ/\text{min}$.

The mechanical properties of nanofibrous mats were tested on a tensile tester (AGS-100A, Shimadzu Co., Japan) with the extension rate of 10 mm/min. The size of the samples was 100 mm length, 20 mm width, 50 mm distance between two clamps.

Table 2
Compositions of nanofibrous mats

Sample	No. ratio of jets (PVA/CA)	Arithmetical weight ratio (PVA/CA)	Real weight ratio (PVA/CA)	Average fiber diameter (nm)
A	4/0	100/0	100/0	190
B	3/1	70/30	77/23	220
C	2/2	45/55	51/49	240
D	1/3	20/80	26/74	290
E	0/4	0/100	0/100	420

3. Results and discussion

3.1. Electrospinning process and determination of composition in blends

Table 1 lists solution properties of PVA and CA. The nanofibrous mats can be fabricated under the given viscosity and conductivity from each polymer solutions. During electrospinning process, a relative high voltage (20 kV) was used to supply the power for four jets electrospinning. The PVA and CA nanofibers were alternatively and continuously deposited on the collector because of the movable multi-jet and the rotatable collector. The throughput of PVA and CA nanofibers was 1.9 and 2.3 mg/min jet when all four jets were placed with the same solution during electrospinning, respectively.

The relation between weight ratio of PVA/CA and number ratio of jets of PVA/CA is given in Table 2. The weight ratio of PVA/CA in calculation was deduced from the throughput of each polymer with corresponding amount of jets. Moreover, the real weight ratio of PVA/CA was investigated through the immersion test. Water was a suitable medium for the immersion test because PVA was soluble in water. From the results of the real weight ratio of PVA/CA, it can be observed that the PVA component in blend nanofibrous mats can be dissolved entirely to leave CA in fiber state. And there was no weight loss for CA nanofibrous mats during the immersion test.

However, some differences were found between the calculation and fact in weight ratio of PVA/CA. One reason maybe was due to that the throughput of PVA and CA was measured when all four jets were placed with the same kind of solution. The distribution of current for different jets was changed when four jets were contained with different kinds of polymer solutions because of their different viscosity and conductivity. A linear relation was found between the currents and flow rates by Shin et al. [3]. The PVA solution has much higher conductivity (18.6 ms/m) than CA solution (0.3 ms/m). Another reason maybe was due to the throughput in electrospinning could not be kept constant for the competition between the mechanical and electric

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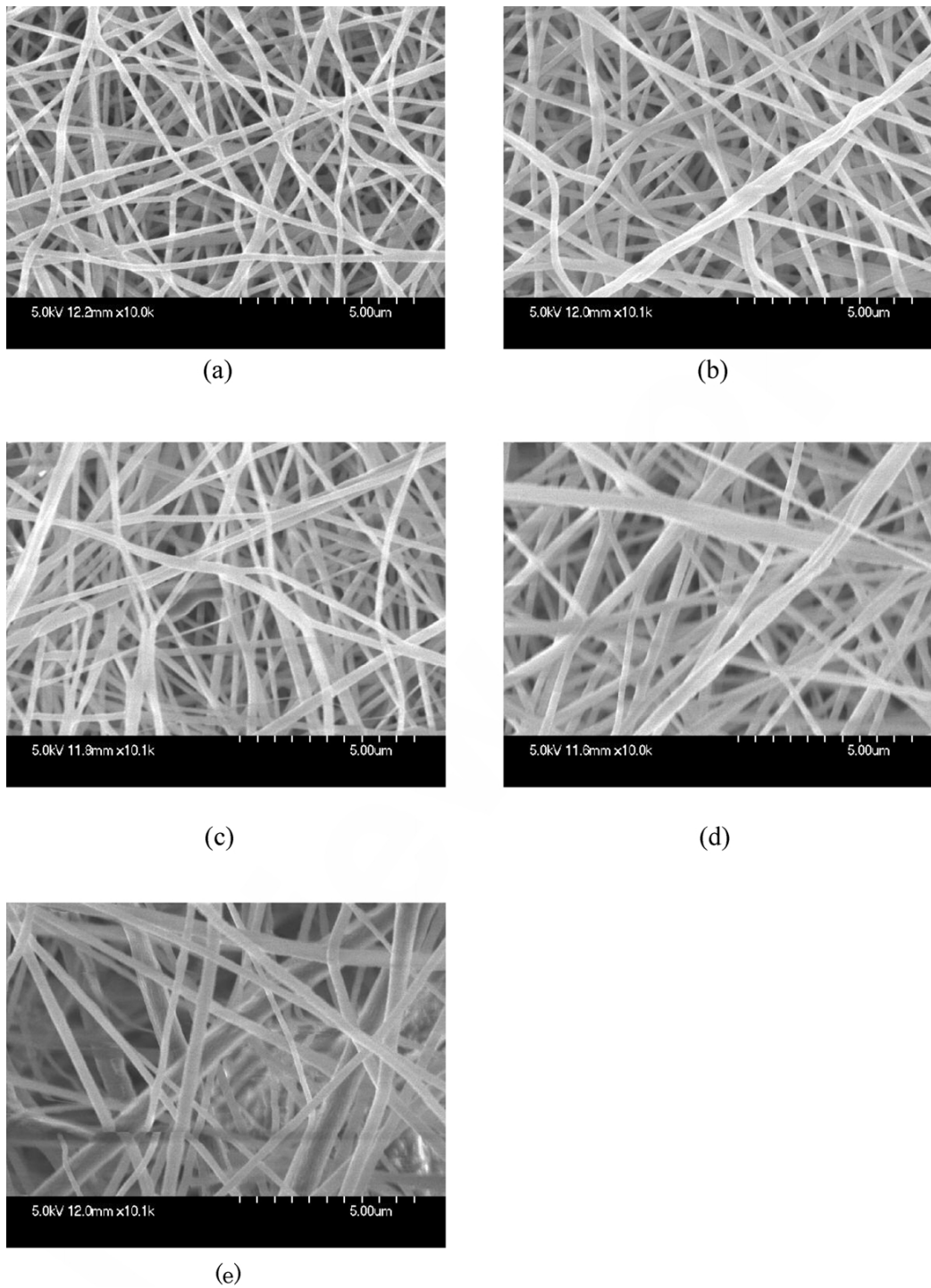
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Fig. 2. FE-SEM photographs of nanofibrous mats with different number ratio of jets of PVA/CA. (a) 4/0; (b) 3/1; (c) 2/2; (d) 1/3; (e) 0/4.

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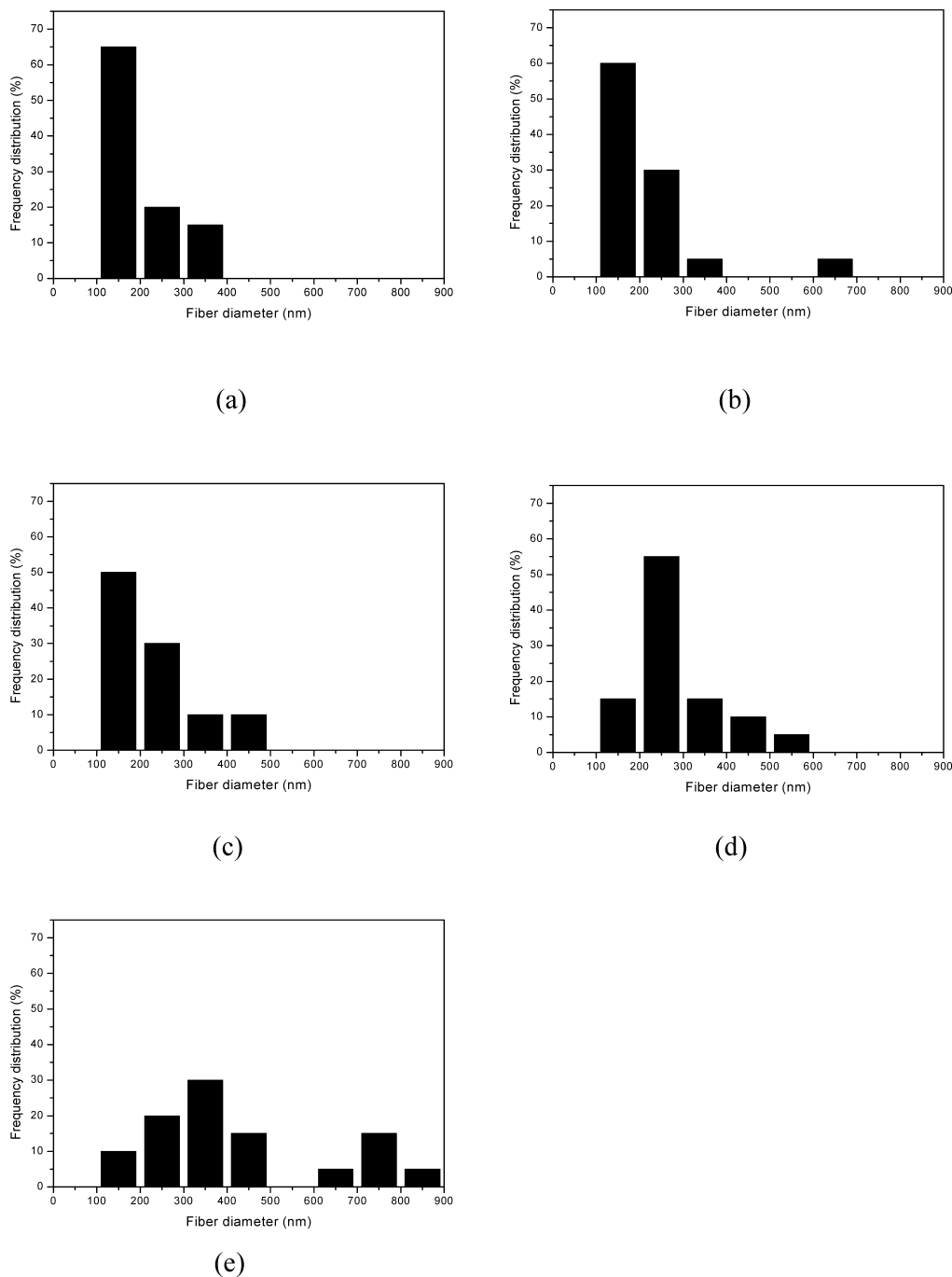


Fig. 3. Nanofiber diameter distributions of nanofibrous mats with different number ratio of jets of PVA/CA. (a) 4/0; (b) 3/1; (c) 2/2; (d) 1/3; (e) 0/4.

forces. Hence, the real content of PVA in blend nanofibrous mats was different with the arithmetical content which only deduced from the throughput.

3.2. Morphology of nanofibrous mats

Fig. 2 shows FE-SEM photographs of PVA, CA, and

blend nanofibers. The morphology of the pure PVA nanofibers (Fig. 2(a)) was regular and had an average diameter of 190 nm. In Fig. 2(e), it was observed that the diameters of pure CA nanofibers were broadly distributed with an average diameter of 420 nm. A similar phenomenon of CA nanofibers morphology was reported by Liu and Hsieh [14]. Fig. 2(b)–(d) provide the morphology of blend

nanofibers of PVA and CA. The diameters of blend nanofibers became irregular because of the existence of CA nanofibers. Meanwhile, the average diameters of blend nanofibers were increased from 220 to 290 nm on decreasing the number ratio of jets of PVA/CA from 3/1 to 1/3 (Table 2).

The diameter distributions of nanofibrous mats with different number ratio of jets of PVA/CA are presented in Fig. 3. The region of distribution of pure PVA nanofibers (Fig. 3(a)) was ranged from 100 to 400 nm and the majority was in the range of 100 to 200 nm. However, the diameters of pure CA nanofibers (Fig. 3(e)) were broadly distributed in the range of 100–900 nm with two major regions. The regions of diameter distributions of blend nanofibrous mats were enlarged and the major region was moved to large diameter when the number ratio of jets of PVA/CA was decreased from 3/1 to 1/3 (Fig. 3(b)–(d)). It can be deduced that the percentage of CA component was increased with decreasing the number ratio of jets of PVA/CA.

3.3. Fourier transform infrared spectroscopy

Fig. 4 gives the FT-IR spectra of nanofibrous mats with different number ratio of jets of PVA/CA. Both PVA nanofibers (curve a in Fig. 4) and CA nanofibers (curve e in Fig. 4) exhibited a number of FT-IR absorption features below 2000 cm^{-1} . These major absorption features appeared at 1740 cm^{-1} (C=O), 1450 cm^{-1} (O=C–OR), 1340 cm^{-1} (–CH₂), and 1110 cm^{-1} (C–O–C) [23,24]. Features above 2000 cm^{-1} are both intense and composition sensitive. They appeared at 2900 cm^{-1} (–CH₂) and 3400 cm^{-1} (–OH).

Additionally, PVA nanofiber has a typical band around 860 cm^{-1} and CA nanofiber has typical bands around 1190 and 1150 cm^{-1} [23,24]. These peaks around 3400 , 2900 and 1450 cm^{-1} became weaker, two shoulder peaks around 1110 cm^{-1} and the peak around 860 cm^{-1} were disappeared on decreasing the number ratio of jets of PVA/CA from 4/0 to 0/4. Meanwhile, the peaks around 1190 and 1150 cm^{-1}

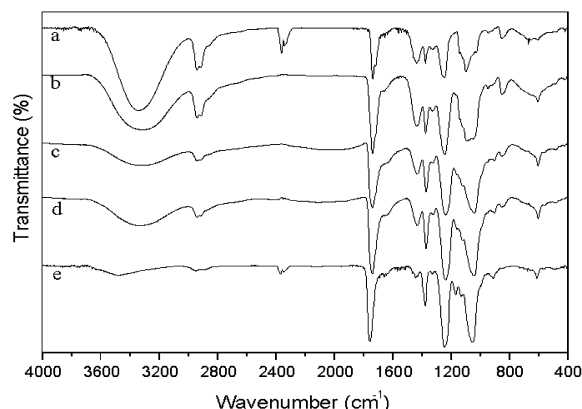


Fig. 4. FT-IR spectra of nanofibrous mats with different number ratio of jets of PVA/CA. (a) 4/0; (b) 3/1; (c) 2/2; (d) 1/3; (e) 0/4.

were more evident with decreasing the number ratio of jets of PVA/CA from 4/0 to 0/4. It was also observed that all the blend nanofibers (curves b to d in Fig. 4) have both IR features of PVA and CA without new peaks. The results demonstrated that there was no chemical reaction between PVA and CA nanofibers, just physical blending. Moreover, the intensities of feature peaks of PVA and CA in blend nanofibrous mats were strongly affected by the weight ratio of PVA/CA. The feature peaks of nanofibrous mats were gradually transformed from PVA to CA with decreasing the number ratio of PVA/CA from 4/0 to 0/4. The regular transforms indicated that PVA and CA nanofibers dispersed into each other very well.

3.4. Wide-angle X-ray diffraction

The WAXD patterns of nanofibrous mats with different number ratio of jets of PVA/CA are shown in Fig. 5. As observed in the curve a of Fig. 5, one peak around $2\theta = 20^\circ$ appeared, corresponding to the (101) plane of PVA semicrystalline in pure PVA nanofibers [11]. Pure CA nanofibers (curve e in Fig. 5) also showed a weak amorphous peak [25]. It indicated the amorphous nature of PVA and CA nanofibers. The intensity of amorphous peaks ($2\theta = 20^\circ$) of nanofibrous mats gradually decreased with decreasing the number ratio of jets of PVA/CA. The characteristics of WAXD patterns of nanofibrous mats were gradually transformed from PVA to CA with decreasing the number ratio of PVA/CA from 4/0 to 0/4. It also proved that the weight ratio of PVA/CA in blend nanofibrous mats can be controlled by changing the number ratio of jets of PVA/CA.

3.5. Mechanical properties

The mechanical properties of electrospun blend nanofibrous mats were strongly influenced by the properties of

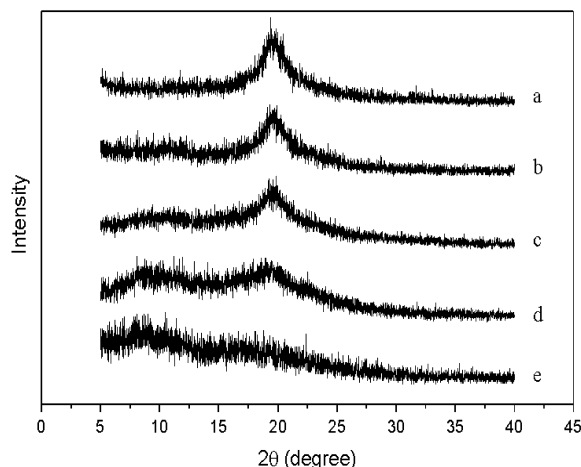


Fig. 5. WAXD patterns of nanofibrous mats with different number ratio of jets of PVA/CA. (a) 4/0; (b) 3/1; (c) 2/2; (d) 1/3; (e) 0/4.

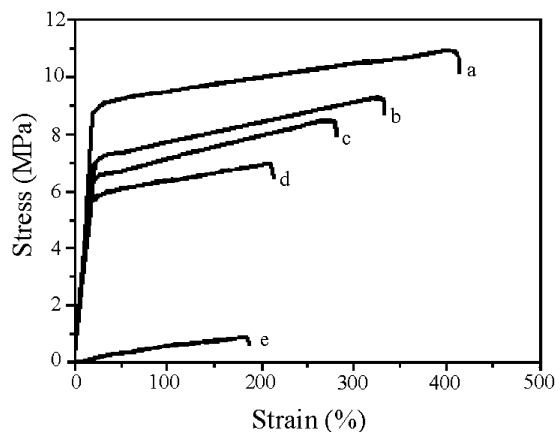


Fig. 6. Stress–strain behavior of nanofibrous mats with different number ratio of jets of PVA/CA. (a) 4/0; (b) 3/1; (c) 2/2; (d) 1/3; (e) 0/4.

each polymer in the blend nanofibrous mats, nanofiber structure, and the interaction between each polymer nanofibers [26]. Stress–strain behavior of nanofibrous mats with different number ratio of jets of PVA/CA is shown in Fig. 6. The nanofibrous mats were broken when the maximum amount of tensile stress (tensile strength) applied to them. After adding with PVA component, the mechanical properties of CA nanofibrous mats were largely reinforced. The resulting modulus, tensile strength, and yield stress of nanofibrous mats are shown in Fig. 7. CA nanofibrous mats (0/4) showed much weaker mechanical properties compared with PVA nanofibrous mats (4/0). The modulus of blend nanofibrous mats were increased from 18.1 to 34.0 MPa with increasing the number ratio of jets of PVA/CA from 1/3 to 3/1. Meanwhile, the tensile strength and yield stress also were increased from 7.0 to 9.4 MPa and from 5.9 to 7.2 MPa on increasing the number ratio of jets of PVA/CA from 1/3 to 3/1, respectively.

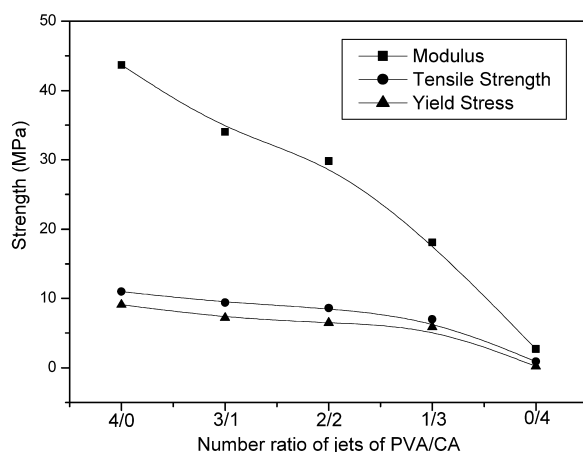


Fig. 7. Modulus, tensile strength and yield stress of nanofibrous mats as a function of number ratio of jets of PVA/CA.

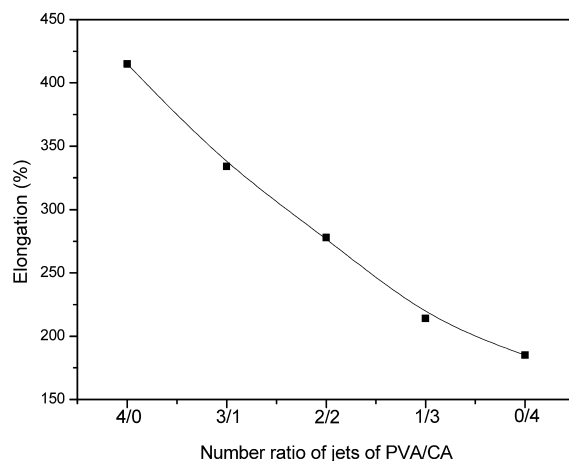


Fig. 8. Elongation of nanofibrous mats as a function of number ratio of jets of PVA/CA.

Fig. 8 presents the elongation of nanofibrous mats as a function of number ratio of jets of PVA/CA. As observed, the elasticity of blend nanofibrous mats was reinforced with addition of PVA component. The breaking elongation of the blend nanofibrous mats gradually increased from 214 to 334% with increasing the number ratio of jets of PVA/CA from 1/3 to 3/1. As a result, the mechanical properties of blend nanofibrous mats were improved with increasing the content of PVA. Moreover, it also indicated that the blend nanofibrous mats have good dispersibility of PVA and CA nanofibers to lead uniform mechanical properties for each sample.

4. Conclusions

Blend biodegradable nanofibrous nonwoven mats with different weight ratio of PVA/CA were successfully fabricated via multi-jet electrospinning. These nanofibrous mats were examined regarding their morphology, dispersibility, and mechanical properties. The results showed the blend nanofibrous mats have good dispersibility because the blend nanofibrous mats have uniform properties for each sample and regular transforms with changing the number ratio of jets of PVA/CA. As a result, the PVA and CA nanofibers were homogenously dispersed into each other. FT-IR results demonstrated that there was no chemical reaction between PVA and CA nanofibers, just physical blending. Additionally, the mechanical properties of CA nanofibrous mats were improved by increasing the content of PVA nanofibers. Furthermore, the multi-component blend nanofibrous mats also can be obtained by increasing the electrospinning jets in this multi-jet electrospinning fashion.

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Exhibit 8

Handbook of Filter Media

2nd Edition

Derek B Purchas and Ken Sutherland



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Cover illustration depicts FilterLink, a synthetic spiral link fabric made into industrial filter belts for a range of applications. FilterLink is a registered Trade Mark of Madison Filter

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CHAPTER 8

Membranes

In filtration terms, membranes started as thin, flexible semi-permeable sheets of regenerated cellulose material, developed to separate species at the molecular and ionic level, their first main application being in the purification of salt and brackish waters by reverse osmosis. The word 'membrane' has stuck to a range of filter media that has expanded enormously from this early form, to embrace solid inflexible ceramic and sintered metal, and an ever-increasing group of polymeric materials, and to applications that now extend well into the microfiltration range. The existence of the membrane as a very effective filtration medium led to the development of the whole field of cross-flow filtration, which also now extends well beyond its reverse osmosis origins.

This chapter provides an introduction to the membrane as a filter medium, but makes no attempt to be a complete reference on membranes, even in filtration, let alone their wider uses. There is here a good deal of information about the ways in which membrane systems are used, but only enough to set the membrane media themselves in context. For a more complete reference to membranes of all kinds, the reader is directed to Keith Scott's *Handbook of Industrial Membranes*⁽¹⁾, on which the corresponding chapter of the first edition of this Handbook was largely based.

8.1 Introduction

The first edition of this Handbook defined membranes as follows:

'A membrane is a thin sheet of material which exhibits some degree of permeability to fluids thereby permitting phase or species separations to be affected for particles in the size range from a few microns down to molecules.'

Any attempt now to provide a succinct but comprehensive definition of a membrane is very much complicated by the immense and ever-growing diversity of membranes available, by the variety of mechanisms by which they function, and by the multiplicity of applications for which they are used. To many people, a membrane remains a thin flexible material, but in filtration terms the term now

covers any medium that can achieve separations at 0.1 μm or below (down to molecular and ionic sizes), and which may be thick or thin, flexible or rigid, organic or inorganic. Many membranes are now employed in microfiltration applications at cut sizes well above 0.1 μm .

The membrane is essentially a surface filtration device, with little or no depth filtration involved in its use. In practice, many membranes are of asymmetric structure and effectively comprise two layers. The active, surface layer is a very thin skin, the permeability of which is of critical importance. The lower, thicker layer is of more open structure, its role being to serve as a mechanical support for the active layer.

This chapter looks firstly at the way membranes are used in filtration applications, and then at the nature of membrane media, and the ways in which they are made. A brief look at membrane characterization is followed by a review of some typical membrane media available on the market, and some guidance as to their selection. It is primarily concerned with the use of membranes in particulate separations, i.e. in microfiltration, but membrane media are now used in such a wide spectrum of applications, with considerable overlap among what were once clearly separate uses, that these other applications are covered here as well.

The membrane represents probably the fastest growing part of the filtration media market (especially if ceramic membranes for hot gas filtration are included). The most important of the changes in the membrane business since the first edition of this Handbook are:

- the extension of membrane media into microfiltration applications;
- the growth in importance of expanded PTFE as a membrane material;
- a corresponding growth of ceramic materials for membranes; and
- the development of techniques for the increase of stabilised fluid flux by the disturbance of boundary layers at the membrane surface.

8.2 Membrane Systems

In order to gain a good grasp of the nature and use of filtration membranes it is first necessary to look at the way in which membranes are used, both in process terms, and in their actual structural format. The fine surface structure of all membranes implies the need for significant pressure drops across the medium in order to achieve adequate fluid fluxes. As a result, membranes need to be contained in pressure-tight housings, and considerable ingenuity is required of the suppliers to achieve sound and efficient operation.

8.2.1 Membrane processes

Historically, membranes were first developed to work at the lowest size levels of separation, the removal of salts, i.e. ionic species, from water at quite high flow rates to produce water of drinkable quality. This application required high working pressures, but over the subsequent years the membranes have become 'looser', and the pressures required have become less, as the membrane has

been used for separations at progressively higher sizes – because membranes have decreased in cost, and so become attractive for an increasingly wide range of applications. The broad spectrum of membrane processes is illustrated in Figure 8.1.

The highest levels of permeability correspond to membranes of relatively coarse microporous structure that permit the transmission of liquids that can be solutions of macromolecules; they reject fine suspended solids down to less than $0.1\ \mu\text{m}$ by *microfiltration* at relatively low differential pressures (1–4 bar). Less permeable membranes, of finer microporous structure, allow passage of solutions of smaller molecules and ions; functioning by *ultrafiltration* at differential pressures up to about 10 bar, they reject finer particles and molecules of molecular weight above about 10 000. Membranes in these two categories (microfiltration and ultrafiltration) are the main theme of this chapter.

Contrasting with these are the semi-permeable membranes of *reverse osmosis* (or *hyperfiltration*), the asymmetric structure of which incorporates a thin non-porous homogeneous skin; under pressures of 30–60 bar, these membranes are capable of the finest possible level of separation, including the rejection of dissolved salts, and the complete removal of bacteria, pyrogens and organics from water. *Nanofiltration* is essentially a form of reverse osmosis operating at pressures in the range 20–40 bar, using a 'looser' membrane so as to restrict rejection to molecules in the molecular weight range 300–1000, and to larger ions (such as Ca^{2+} and Mg^{2+}), and the very finest particles.

These four specifically liquid filtration-related membrane processes are shown in Figure 8.2, with main applications for each. It should be noted that the separation size ranges overlap at each end.

Membranes incorporating thin layers of dense non-porous material utilize *gas permeation* to separate gases (such as hydrogen recovery from refinery exit streams, or the separation of oxygen and nitrogen from air), and *pervaporation* to separate miscible liquids, as an alternative to fractional distillation. Yet other mechanisms, utilizing electrically charged or ion exchange membranes, are involved in processes such as *electrodialysis*, and in fuel cells.

The full range of membrane processes is listed in Table 8.1, with typical membrane types, and associated driving forces and typical applications.

It should be noted that the use of the term 'non-porous' in the above definitions relates to the impossibility of the flow of fluids carrying particles through continuous open pores in the medium. Such materials are still permeable to molecular or ionic species by means of diffusion through the solid mass of the non-porous layer.

Because of the very fine nature of the membrane media, it is normal practice to employ a filter, ahead of the membrane unit, that is intended to remove any particulate material that might interfere with the membrane process. This is especially necessary where the flow passages are very narrow, such as in hollow fibre membranes. In fact, some membranes themselves are used as prefilters to membranes operating at a finer degree of separation. Thus there will normally be a microfilter ahead of an ultrafiltration or reverse osmosis membrane, but there may also be an ultrafiltration membrane ahead of a reverse osmosis step.

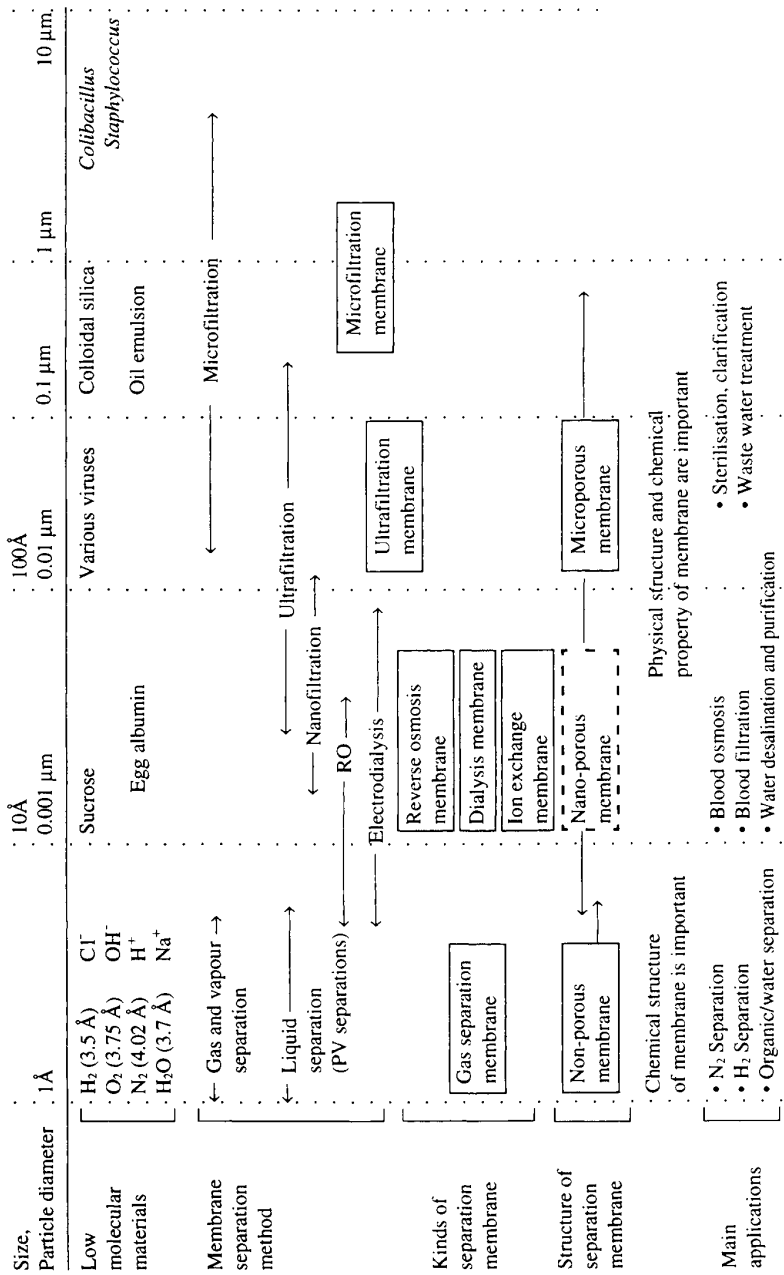


Figure 8.1. An overview of membrane separation technology.

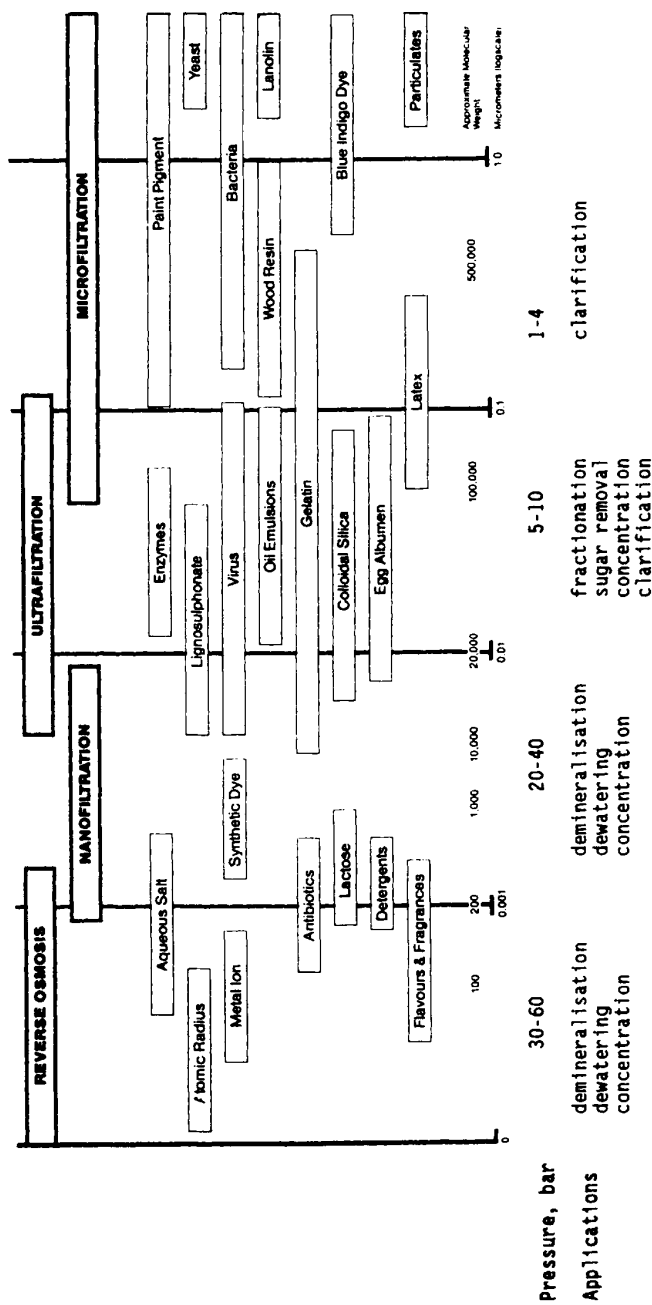


Figure 8.2. Summary of membrane liquid filtration processes.

8.2.1.1 Operational modes

Two distinct modes of filtration are relevant to membrane media, as shown schematically in Figure 8.3. *Dead-end* (or through-flow) *filtration* is the conventional mode for all filtration, with the feed flow perpendicular to the membrane surface; essentially all of the fluid passes through the membrane whilst the separated particles accumulate on its surface as a layer of retained solids. This build-up of solid particles leads to a progressive increase in the resistance to filtration through the membrane, to the point where flow eventually stops.

Table 8.1 Membrane separations and materials

Membrane separation	Membrane type	Driving force	Applications
Microfiltration	Symmetric and asymmetric microporous	Hydrostatic pressure	Clarification, sterile filtration
Ultrafiltration	Asymmetric microporous	Hydrostatic pressure	Separation of macromolecular solutions
Nanofiltration	Asymmetric	Hydrostatic pressure	Separation of small organic compounds and selected salts from solutions
Reverse osmosis or hyperfiltration	Asymmetric, composite with homogenous skin	Hydrostatic pressure	Separation of micro-solutes and salts from solutions
Gas permeation	Asymmetric or composite, homogenous or porous polymer	Hydrostatic pressure	Separation of gas mixtures
Dialysis	Symmetric microporous	Concentration gradient	Separation of micro-solutes and salts from macromolecular solutions
Pervaporation	Asymmetric, composite non-porous	Concentration gradient, vapour pressure	Separation of mixtures of volatile liquids
Vapour permeation	Composite non-porous	Concentration gradient	Separation of volatile vapours from gases and vapours
Membrane distillation	Microporous	Temperature	Separation of water from non-volatile solutes
Electrodialysis	Ion exchange, homogeneous or microporous polymer	Electrical potential	Separation of ions from water and non-ionic solutes
Electrofiltration	Microporous charged membrane	Electrical potential	Dewatering of solutions of suspended solids
Liquid membranes	Microporous, liquid carrier	Concentration, reaction	Separation of ions and solutes from aqueous solutions

The formation of this surface filter cake can be reduced or eliminated by the use of tangential or *cross-flow filtration*. Only part of the fluid now passes through the membrane as filtrate (or, more correctly, permeate, since some membrane processes operate by permeation rather than filtration); the retained part, or retentate, consequently becomes more concentrated in particulate or solute species. The extent to which cross-flow successfully prevents the surface of the membrane being fouled by deposited particles is dependent on a variety of factors, especially the cross-flow velocity. Chemical and/or mechanical procedures are usually required to clean (and sterilize) the membrane, which must be able to withstand the associated mechanical, chemical and thermal stresses. Whereas microfiltration utilizes both the dead-end and cross-flow filtration, cross-flow is the usual mode for the other membrane filtration processes, and has grown to its present level of importance from its beginnings in reverse osmosis.

8.2.1.2 Operational problems

The build-up of a ‘fouling’ layer on the surface of a membrane is one of the most serious problems in membrane processes. The term ‘fouling’, rather than the more familiar ‘filter cake’, arose from the origins of membrane processes in molecular separations, where macromolecular proteins would separate on to the membrane surface as a slimy, gel layer, which rapidly reduced the fluid flux through the membrane. Fouling layers have to be removed periodically by cleaning, as mentioned above, but much ingenuity is employed by membrane system designers to minimize fouling layer formation.

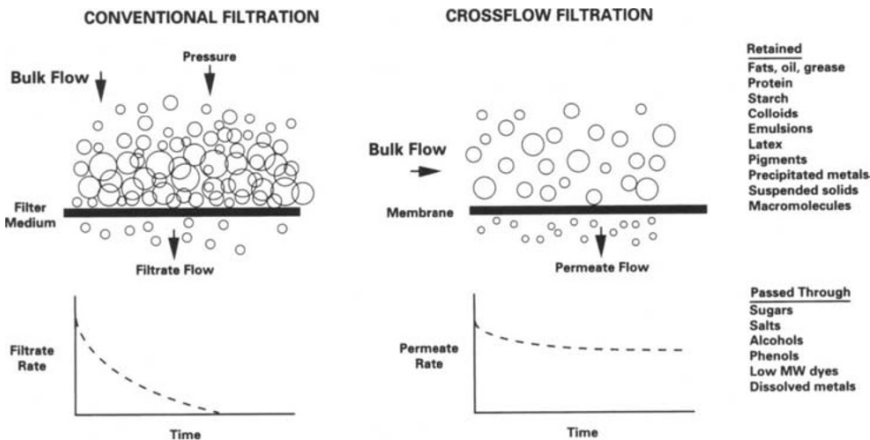


Figure 8.3. Comparing cross-flow filtration with conventional filtration.

Another operating problem, concentration polarization, affects the membrane processes dealing with suspended or dissolved species. The molecules to be separated (i.e. kept in the retentate) diffuse through the liquid close to the membrane surface and become much more concentrated at the surface, creating a different kind of barrier to liquid flow, and so reducing flux. In the same way, the particulate matter accumulates in the liquid as it approaches the boundary layer, creating a similar resistance to liquid flow.

There are basically three types of method employed to reduce fouling and/or concentration polarization, and so increase flux rates:

- changes in the surface characteristics of the membrane;
- conditioning of the feed slurry/solution; and
- modifications in the way the fluid/membrane is operated.

An example of the way in which the membrane material itself may be modified is given by Kalsep's Kalmem LF membrane⁽²⁾. This is basically a polyethersulphone (PES) material, with polymeric low-fouling additives incorporated into the PES. The chemically modified surface is permanently hydrophilic, and can be made with pore sizes in the microfiltration and ultrafiltration ranges.

The surface of the membrane needs to be as smooth as possible, and the slurry or solution as free as possible of material that will foul the surface. Operational modifications are generally designed to create some kind of shearing or scouring of the fouling layer. Some of these are mechanical, and are discussed in the next section, while the use of a two-phase (gas/liquid) flow⁽³⁾ is growing in importance.

8.2.2 Membrane formats

Depending on the properties of the material used, membranes may be produced in the following geometrical forms:

- flat sheets – self-supporting or backed by a supporting substrate (and including the sheets when rolled up into a spiral-wound configuration);
- tubes – self-supporting or backed by a supporting substrate, typically 12–24 mm in internal diameter; and
- hollow fibres – typically 40 µm internal diameter × 80 µm outside diameter.

All of these forms are mostly utilized by being incorporated in filter cartridges, such as are described in Chapter 9. Some of the more robust types of membrane sheets can be used in industrial process filters such as filter presses. For laboratory duties, sheet membranes are available as discs in a range of standard diameters; appropriate grades are also supplied in roll form.

Because of the high fluid flow resistance of most membranes, they are usually operated in some kind of module, which allows the largest possible filtration area

to be packed into the smallest possible equipment volume. There are six distinct styles of module in which membrane media are employed: flat sheet, pleated sheet, spiral wound sheet, tubes or tube bundles, perforated blocks and hollow fibre bundles. Polymeric membranes are used in almost all forms – except the perforated block, which is very largely restricted to inorganic materials.

Flat sheet modules are based on the principle of the plate-and-frame filter press, comprising an alternating stack of sheets of membrane media and separator plates through which the feed, retentate and permeate flow. These are the least compact of the different module formats, and are correspondingly the least used. Figures 8.4 and 8.5 show, respectively, a laboratory and a free-standing industrial flat sheet module of this type, which can be used for microfiltration or ultrafiltration. Most polymeric materials, and much of the inorganic materials are available as flat sheets or rolls, and can be used in this type of module, which finds most application in laboratory and pilot plant. For example, Tami Industries KaCeram media are available for microfiltration in the range 0.14–1.4 μm , and for ultrafiltration in the range 15–300 kD.

If the flat sheet medium is sufficiently flexible, then it can be pleated, just as can any other paper-like material. In this way, a membrane can be used for absolute air filtration, as in Chapter 5, as a filter bag for gas cleaning or as a cartridge filter, as described in Chapter 9. Pleating is possible for most polymeric media, for some metallic media, and even for some ceramics.

Membrane materials can also be made or cut into long, wide strips, which are then rolled up around a central former, with appropriate sheets of spacers and

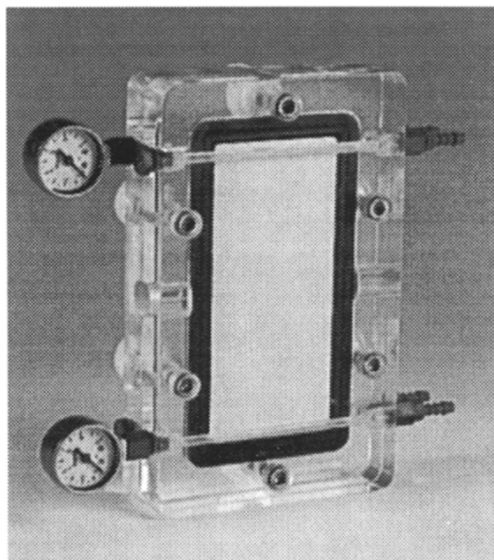


Figure 8.4. A laboratory scale 'Pleiade Rayflow 100' cross-flow filter with a membrane area of 100 cm^2 . (Photograph: Ultra-Tech Services Ltd)

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supports sandwiched between the membrane layers, to create a *spiral wound module*, as illustrated in Figure 8.6. Such a construction gives a very compact unit containing a large membrane area. For example, a module that is just 200 mm in diameter and 900 mm long may contain up to 23 m² of active membrane. Because the sandwich structure operates with very small clearances between the sheets, it is essential that adequate prefiltration is undertaken of the feed liquid. Spiral wound modules are used for microfiltration and ultrafiltration.

Simple tubes are feasible as membrane formats, but unlikely outside the laboratory, because of their small area. Much more likely, on the industrial scale, are *tubular modules*, with bundles of tubes constructed in the same form as a shell-and-tube heat exchanger, as shown in Figure 8.7. In the version illustrated, each replaceable 12.5 mm diameter membrane tube fits into a perforated stainless steel support tube. The membrane tubes, which can be several metres in length, are of composite construction, with, for example, a cellulose acetate membrane cast on to the internal surface of a synthetic fibre support tube.

An alternative approach is offered by the three options illustrated in Figure 8.8, all of these being disposable items. The single 25 mm i.d. tube version has an inside layer of PES membrane cast onto an epoxy resin reinforced fibreglass support, with an outside protective tube of PVC. The Ultra-cor VII tube is divided internally by a bundle of seven 12.5 mm membrane tubes, thereby increasing the available filtration area per unit length; this concept is extended further in the Super-cor tube, with its array of 21 internal tubes.

The tubular formats are the ones most likely to be adopted for inorganic media, especially for ceramics, where the idea is further extended into the *perforated block* structure illustrated in Figure 8.9. A monolithic block, of very coarsely porous ceramic, shaped to fit into a containing tube, is perforated with a number of cylindrical channels parallel to its length. A ceramic membrane layer is then

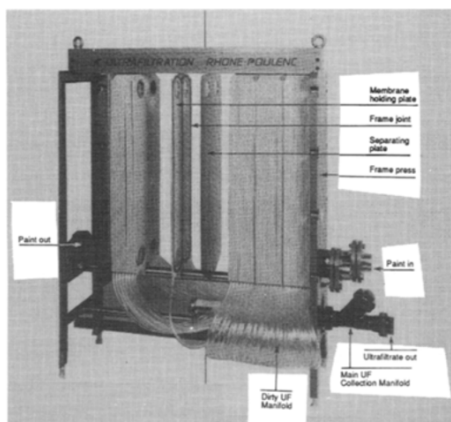


Figure 8.5. A 'Pleiade' UFP71 ultrafiltration filter, with a total membrane area up to 21 m² can be used on applications such as recovering paint from a car spraying unit.

laid down on the inner surface. A very wide range of channel number and shape is possible with this kind of construction – the range currently marketed by Tami Industries covers 14 different shapes, with up to 39 individual channels offering hydraulic diameters from 2 to 14 mm. These all have quite thin walls through which the permeate must pass.

Hollow fibre modules are also in the basic format of a shell-and-tube heat exchanger, but now the tubes are hollow fibres with outside diameters ranging from a few millimetres down to as fine as a human hair (about 80 μm). These fibres, which may be several hundreds in number, are assembled as a closely packed bundle, sealed at its ends into resin plugs, either at opposite ends of the containing shell, as in Figure 8.10, or with the bundle looped round and the ends sealed into the same plug, as in Figure 8.11. As indicated by these two figures,

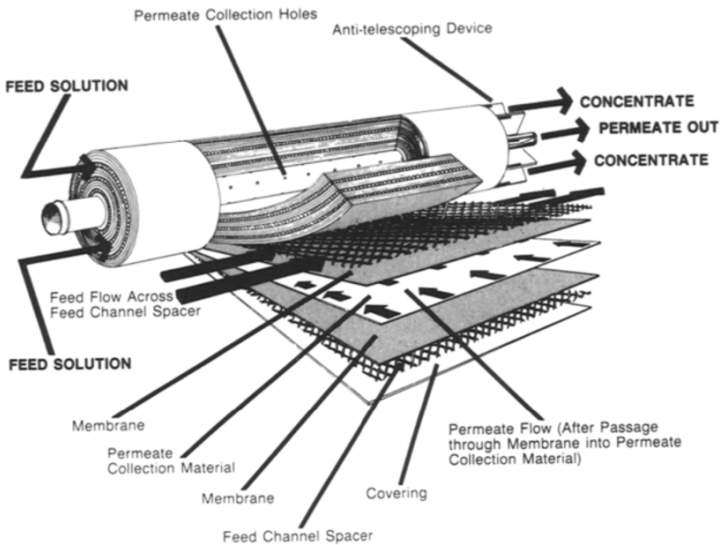


Figure 8.6. A spirally wound MF or UF module.

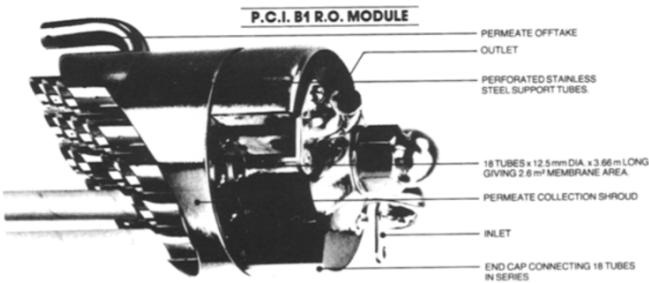


Figure 8.7. Part of a PCI tubular RO module.

the fluid to permeate flow direction can be either in-to-out or out-to-in for hollow fibre applications.

A great advantage of the hollow fibre module is its compactness in relation to its very large filtration area per unit volume, typically $8000\text{ m}^2/\text{m}^3$. For example, with a Koch standard 1.09 m long, 0.127 m diameter module, the membrane area is 3.7 m^2 with 2.7 mm diameter fibres, and 12.3 m^2 with 0.5 mm fibres.

A general comparison of the main types of membrane module is provided in Table 8.2.

In all of the module designs discussed above the membrane medium is stationary, and the fluid flows across (or occasionally through) it. However, as stated earlier, the problems of fouling and concentration polarization can be at

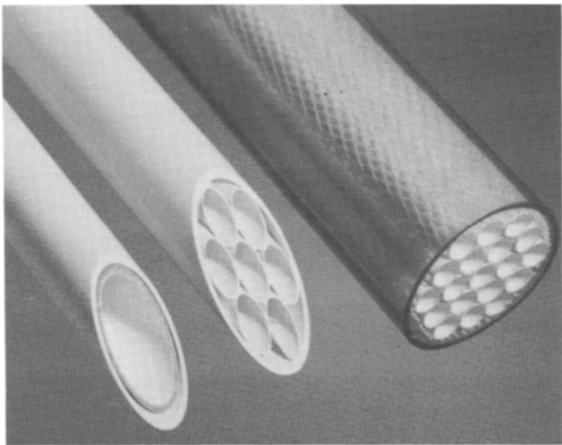


Figure 8.8. Tubular MF/UF/RO options: single tube, 'Ultra-cor VII' and 'Super-cor'.

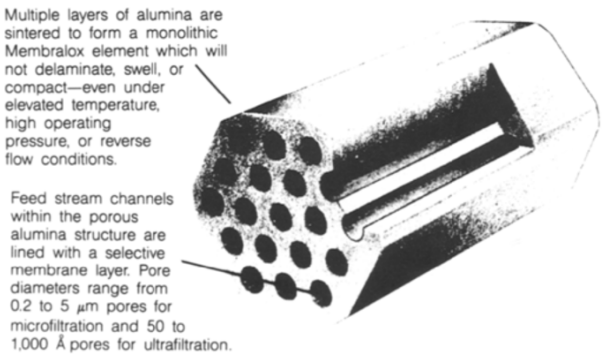


Figure 8.9. Sectional view of a 19-channel ceramic element. (Illustration: APV Membrantechnologie GmbH)

least partly reduced if an element of shear can be applied to the boundary layer at the membrane surface. This can be achieved either by causing the membrane to rotate or oscillate with relation to the fluid flow. Still very much in the development phase, the rotating moving membranes can be in the form of a disc⁽⁴⁾ or a cylinder⁽⁵⁾, while a stack of discs is caused to oscillate in another variant⁽⁶⁾, which has reached commercial use. SpinTek Filtration Systems introduced a rotating ultrafiltration unit, using a ceramic membrane, into commercial use in mid-1999.

8.3 Membrane Materials

To be effective for separation, membranes should exhibit appropriate characteristics, such as good chemical resistance (to both feed and cleaning fluids), mechanical stability, thermal stability, high permeability, high selectivity and general stability in operation; for guidance on the chemical compatibility of membrane materials, see Table 8.3 (originating with Millipore Inc), or the more detailed Table 2.4 for fabrics in Chapter 2.

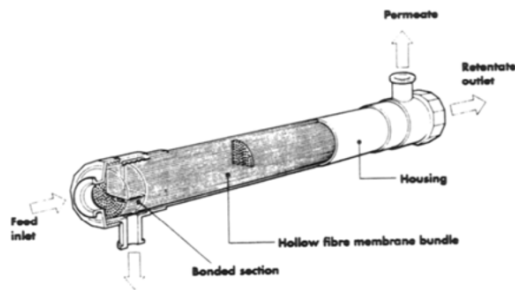


Figure 8.10. A hollow tube module with in-to-out flow.

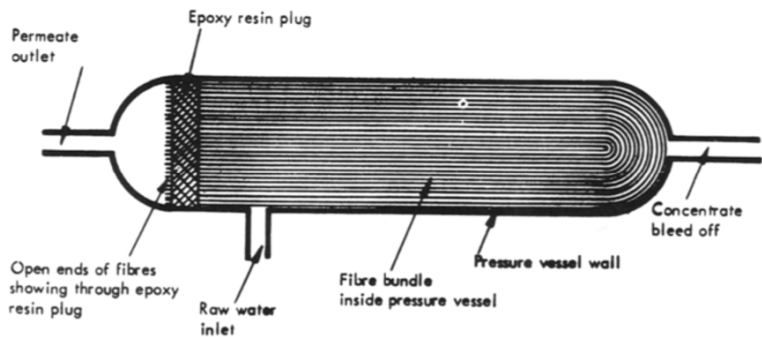


Figure 8.11. A hollow tube RO module with out-to-in flow.

Table 8.2 General comparison of characteristics of membranes*Tubular membranes*

1. Tubular modules have relatively large channel diameters, and are capable of handling feed streams and slurries containing fairly large particles. The general rule of thumb is that the largest particle that can be processed in a membrane module should be less than one-tenth the channel height. Thus feed streams containing particles as large as 125 μm can be processed in 1.25 mm tubular units.
2. Tubular units of 1.25–2.5 cm diameters are operated under turbulent flow conditions with recommended velocities of 2–6 m per second. Flow rates are 15–60 l per minute per tube, depending on the tube diameter. Reynolds numbers are usually greater than 10 000.
3. Pressure drop averages 2–3 psi per 2.4–3.6 m tube. Thus, typical pressure drops for 12–25 mm tubes will be approximately 30–40 psig (2–2.5 bar) for UF units operating in parallel flow under these flow conditions. This combination of pressure drop and high flow rates gives high energy consumption.
4. The open tube design and the high Reynolds numbers make it easy to clean by standard clean-in-place techniques. It is also possible to insert scouring balls or rods to help clean the membrane.
5. Tubular units have the lowest surface area to volume ratio of all module configurations.
6. In certain modules the individual membranes can be replaced fairly easily in plant resulting in considerable savings in transportation costs and membrane costs.
7. Tubular module costs vary widely from about \$100 to 800/ m^2 for replacement membranes of cellulose acetate, polysulphone or composites.

Hollow fibre modules

1. The recommended operating velocity in the UF hollow fibre system is around 0.5–2.5 m/s. This results in Reynolds numbers of 500–3000. Hollow fibres thus operate in the laminar flow region.
2. Shear rates are relatively high in hollow fibres due to the combination of thin channels and high velocity. Shear rates at the wall are 4000–14 000/s.
3. Hollow fibres have the highest surface area-to-volume ratio. Hold-up volume is low, typically 0.5 l in a typical 'short' cartridge of 1.4–1.7 m^2 membrane area.
4. Pressure drops are typically 0.3–1.3 bar depending on the flow rate. The combination of modest pressure drop and flow rates make hollow fibre modules very economic in energy consumption.
5. Hollow fibres have only a modest maximum pressure rating of about 1.8 bar. The short (30 cm) cartridge can withstand pressures up to about 2.4 bar at low temperatures (less than 30°C). Several process streams are dilute enough to permit UF operation at pressures much higher than the present 1.7 bar limiting transmembrane pressure. In addition, since the flow rate is proportional to pressure drop, flow rates are limited since the inlet pressure cannot exceed 1.7 bar. This can be problematic with highly viscous solutions, especially with long cartridges.
6. The small fibre diameters make them susceptible to plugging at the cartridge inlet. To prevent this the feed should be prefiltered to at least 10 μm .
7. Hollow fibres are suitable for 'back-flushing' because the fibres are self-supporting. This vastly improves performance due to cleaning *in situ* potential.
8. Replacement membrane costs are relatively high. Damage to one single fibre out of the 50–3000 in a bundle generally means the entire cartridge has to be replaced. However, it is possible to repair membrane fibres *in situ* in certain cases.
9. The cost is about \$700 per 7.5 cm industrial cartridge, regardless of surface area. Replacement cost is about \$230–350/ m^2 .

Plate

1. The typical plate channel height is between 0.5 and 1.0 mm. UF systems operate under laminar-flow, high shear conditions. The channel length (the distance between the inlet and outlet ports) is between 6 and 60 cm. The Grober equation agrees reasonably well with experiment in the Reynolds number range of 100–3000 for slits of channel height 0.4–1.0 mm.

Table 8.2 (continued)

2. The permeate from each pair of membranes can be visually observed in the plastic tubing coming from each support plate. This is convenient for several reasons, e.g. detection of leaks in a particular membrane pair, if samples need to be taken for analysis, or if flux measurement as a function of capacity needs to be made.
3. Replacement of membranes on site is relatively easy provided that care is taken when closing the stack of plates together. The previously embedded grooves of the unreplaced plates must match exactly as they were previously, or else leakage of feed can occur.
4. In horizontal modules, the flow is parallel through all channels at velocities of about 2 m/s. For a stack of plates, this can result in a pressure drop of about 10 bar. Plate-and-frame systems tend to be intermediate between spiral-wound and tubular systems in energy consumption for recirculation.
5. Membranes are currently about \$120/m² for cellulose acetate, \$230/m² for non-cellulosic RO membranes, and \$140/m² for polysulphone membranes.
6. Surface area-to-volume ratio is fairly high, averaging about 600–1000 m²/m³.

Spiral wound

1. In spiral-wound modules the feed channel height is controlled essentially by the thickness of the mesh-like spacer in the feed channel. Spacers of 0.76 or 1.1 mm are most common. The advantage of a narrow channel height is that much more membrane area can be packed into a given pressure vessel.
2. A larger channel height, while reducing the surface area-to-volume ration slightly, may be more desirable to minimize pressure drops and reduce feed channel plugging. The general rule of prefiltering to one-tenth the channel height is modified for the spiral-wound unit due to the presence of the spacer which reduces the free volume in the channel. Prefiltration of the feed down to 5–25 μ m is recommended for the 0.76 mm spacer-module, and 25–50 μ m for the 1.1 mm channel.
3. Lengths of individual membrane assemblies vary from 1 to 6 feet (0.3–2 m). When calculating the surface area of a spiral-wound membrane, it is convenient to consider it as two flat-sheets, although the *effective* membrane area of spiral-wound modules must allow for gluing the membrane sandwich, for fixing the fourth side to the permeate collection tube and the outer periphery.
4. The hydrodynamics in the spiral-wound module is not too clear. The velocity in spiral-wound units ranges from 10 to 60 cm/s, being higher for the large mesh spacers. These are 'superficial' velocities, however, since the volume occupied by the mesh-like spacer in the feed channel is neglected. These velocities correspond to Reynolds numbers of 100–1300. Technically, this is in the laminar flow region, but the additional turbulence contributed by the spacers means that the flow is in the turbulent region.
5. Surface area-to-volume ratio is fairly high, averaging about 600–1000 m²/m³.
6. Pressure drops in the feed channel are relatively high due to the effect of the spacer. At a superficial velocity of 25 cm/s the pressure drop is around 1–1.4 bar. This high pressure drop can give rise to a 'telescoping' effect at high flow rates, i.e. the spiral pushes itself out in the direction of flow. This can damage the membrane and so anti-telescoping devices are used at the downstream end of the membrane element to prevent this.
7. The combination of the low flow rates, pressure drops and relatively high turbulence makes this an economic module in terms of power consumption. A problem with the mesh spacers is the creation of 'dead' spots directly behind the mesh in the flow path. This may cause particles to 'hang up' in the mesh network, resulting in cleaning problems. This makes it difficult to process feeds containing suspended particles, especially if it is a concentrated slurry and a high recovery of the particles is required. Spiral modules work best on relatively clean feed streams with a minimum of suspended matter.
8. Capital costs are quite low. The membrane element can be recovered from the pressure vessel and returned to the factory for reassembling new membranes. Replacement membranes are priced typically at \$35–140/m² for cellulose acetate, polyvinylidenedifluoride, and polysulphone membranes.

Table 8.3 Chemical compatibility of membrane materials

	Cellulose acetate	Hydrophobic PVDF	Hydrophilic PVDF	MF-Millipore cellulose esters	Fluoropore PTFE	Mitex PTFE	Isopore PC polycarbonate	Isopore PET polycarbonate	AN and PP polypropylene
<i>Acids</i>									
Acetic acid, glacial	X	●	●	X	●	●	O	●	●
Acetic acid, 5%	●	●	●	●	●	●	●	-	●
Boric acid	●	●	●	●	●	●	●	-	●
Hydrochloric acid (conc.)	X	●	●	X	●	●	●	X	●
Hydrofluoric acid	X	●	●	X	●	●	●	X	O
Nitric acid (conc.)	X	O	X	X	O	●	●	X	O
Sulphuric acid (conc.)	X	●	X	X	O	●	X	X	●
<i>Bases</i>									
Ammonium hydroxide (6N)	X	●	X	X	●	●	X	O	●
Sodium hydroxide (conc.)	X	●	X	X	●	●	X	X	●
<i>Solvents</i>									
Acetone	X	X	X	X	●	●	O	●	●
Acetonitrile	X	●	O	X	●	●	-	-	O
Amyl acetate	X	●	●	X	●	●	●	●	X
Amyl alcohol	X	●	●	X	●	●	●	●	●
Benzene	X	●	●	●	O	●	O	●	O
Benzyl alcohol (1%)	O	●	●	●	●	●	●	●	●
Brine (sea water)	●	●	●	●	●	●	●	●	●
Butyl alcohol	●	●	●	●	●	●	●	●	O
Carbon tetrachloride	X	●	●	●	O	●	O	●	X
Cellosolve (ethyl)	X	●	●	X	●	●	-	●	O
Chloroform	X	●	●	●	O	●	X	●	O
Cyclohexanone	X	●	●	X	●	●	●	●	X
Dimethylacetamide	X	X	X	X	●	●	-	-	O
Dimethylformamide	X	X	X	X	●	●	X	●	●
Dioxane	X	●	●	X	●	●	X	●	O
DMSO	X	●	●	X	●	●	X	●	●
Ethyl alcohol	●	●	●	O	●	●	●	●	●
Ethers	O	●	●	●	●	●	●	●	X
Ethyl acetate	X	●	●	X	●	●	O	●	●
Ethylene glycol	●	●	●	X	●	●	●	●	●
Formaldehyde	●	●	●	X	●	●	●	●	●
Freon TF or PCA	X	●	●	●	●	●	●	●	X
Gasoline	X	●	●	●	●	●	●	●	●
Glycerine (glycerol)	●	●	●	●	●	●	●	●	●
Hexane	X	●	●	●	●	●	●	●	●
Hydrogen peroxide (3%)	X	●	●	X	●	●	●	●	●
Hypo (photo)	-	●	●	●	●	●	-	●	●
Isobutyl alcohol	●	●	●	●	●	●	●	●	●
Isopropyl acetate	O	●	●	X	●	●	-	●	●
Isopropyl alcohol	●	●	●	X	●	●	●	●	●
Kerosene	X	●	●	●	●	●	●	●	●

Table 8.3 (continued)

	Cellulose acetate	Hydrophobic PVDF	Hydrophilic PVDF	MF-Millipore cellulose esters	Fluoropore PTFE	Mitex PTFE	Isopore PC polycarbonate	Isopore PET polycarbonate	AN and PP polypropylene
Methyl alcohol	●	●	●	X	●	●	●	●	●
Methylene chloride	X	X	●	X	O	●	X	●	X
MEK	X	X	X	X	●	●	O	●	●
MIBK	X	●	X	X	●	●	-	-	●
Mineral spirits	X	●	●	●	●	●	●	●	●
Nitrobenzene	X	●	●	X	●	●	X	●	●
Paraldehyde	X	●	●	X	●	●	-	-	-
Ozone (10 ppm in water)	X	●	●	●	●	●	●	●	●
Pet base oils	X	●	●	●	●	●	●	-	-
Pentane	X	●	●	●	●	●	●	●	X
Perchloroethylene	X	●	●	●	O	●	●	●	X
Petroleum ether	X	●	●	●	●	●	●	●	X
Phenol (5.0%)	X	●	●	●	●	●	-	●	●
Pyridine	X	●	●	X	●	●	X	●	●
Silicon oils	X	●	●	●	●	●	●	●	●
Toluene	X	●	●	●	O	●	O	●	O
Trichloroethane	X	●	●	●	O	●	O	●	X
Trichloroethylene	X	●	●	●	O	●	X	●	X
TFA	X	●	O	X	●	●	-	-	●
THF	X	●	●	X	●	●	X	●	O
Xylene	X	●	●	●	O	●	●	●	O
Gases									
Helium	X	●	●	●	●	●	●	●	●
Hydrogen	X	●	●	●	●	●	●	●	●
Nitrogen	X	●	●	●	●	●	●	●	●
Ozone	X	X	X	X	X	●	●	O	O

Codes: ● = recommended; O=limited applications, testing prior to use is recommended;
X=not recommended.

Recommendations are based upon static soak for 72 h at 25°C and atmospheric pressure. Dynamic (operating) conditions at moderate (± 10%) fluctuation will not change the recommendations, but high liquid temperature may do so in some cases.

8.3.1 Range of membrane materials

Originally, all membranes were based on natural materials or derivatives of natural cellulose. Whilst cellulosic media continue to play an important role in certain areas of application, the major source of membranes is now synthetic polymers, some of which are included in Table 8.4. There is an immense variety of polymeric materials available as filter media, including grades with specially

Table 8.4 Typical characteristics and applications of microfiltration membranes

Material	Characteristics	Typical applications
Polysulphone	An inherently hydrophilic polysulphone membrane with excellent flow rates, low extractables, broad chemical compatibility, high mechanical strength and temperature resistance.	Food and beverages Pharmaceuticals Semiconductor water Serum
Nylon	Hydrophilic membrane with high tensile strength. Very high flow rates, long life and low extractables. Offers excellent chemical compatibility.	Semiconductor water Chemicals Beverages
PTFE	Naturally hydrophobic membrane laminated to a polypropylene support for extra durability and strength. Superior chemical and temperature resistance.	Air and gases Pharmaceuticals Aggressive chemicals
Acrylic copolymer	Inherently hydrophilic copolymer with strong nonwoven polyester fabric support. Offers high flow rates, low differential pressures and low extractables.	Semiconductor water Pharmaceuticals Food and beverages
Polypropylene	Naturally hydrophobic membrane and chemically inert. Broad pH stability, high temperature resistance and high flow rates.	Chemicals Microelectronics Pharmaceuticals
Glass	Nominal 1.0 mm fine borosilicate glass fibre. High flow rates at moderate differential pressures. Good wet strength and high dirt-holding capacity.	Chemicals Serum Beverages
Polycarbonate	Hydrophilic membrane, unique pore structure and capture, strong, flexible, high flow rate, thermal stability, non-extractable.	Pharmaceuticals Air pollution Laboratory analysis
Cellulose	Hydrophilic membrane. General purpose, with limited thermal and mechanical stability. Some extractables.	Air pollution Microbiology Foods and pharmaceutical

developed properties: hydrophobic or hydrophilic, anionic or cationic, for specific filtration applications.

The range of synthetic polymers used for membrane media includes:

- acrylics
 - polyacrylonitrile (PAN)
 - acrylic copolymers
- amides and imides
 - nylons and aliphatic polyamides
 - polyaramids (aromatic amides)
 - polyimide and polyetherimide (PEI)

- esters
 - polycarbonate (PC)
 - polyethylene terephthalate (PET) and polybutylene terephthalate (PBT)
- fluoropolymers
 - polyvinylidenedifluoride (PVDF)
 - polytetrafluoroethylene (mostly as ePTFE)
- ketones and sulphones
 - polyetherketone (PEK) and polyetheretherketone (PEEK)
 - polysulphone, polyethersulphone (PES)
- olefins
 - polyethylene (usually high density) (HDPE)
 - polypropylene (PP).

Of these, PC, ePTFE and PES are among the fastest growing in importance. Most of these types of membrane material are reviewed in the next section.

During the last 20 years or so, inorganic materials such as ceramics and metals have become of increasing significance as membrane materials. The introduction of these, despite their being nearly an order of magnitude more expensive than their organic counterparts, has occurred because of their much-improved operating lifetimes, their robustness, their greater tolerance to extreme conditions of operation, such as higher temperature and aggressive chemicals, and the subsequent overall saving in lifetime costs.

Apart from the doped PES referred to above, in Section 8.2.1, for anti-fouling performance, most membranes have a single polymer (or copolymer) as the active layer. A quite different kind of membrane, the *affinity membrane*, is developing rapidly as a separation tool⁽⁷⁾, able to separate molecular species by their chemical characteristics, rather than by size. These are based on the molecular recognition technology that won the 1987 Nobel Prize for Chemistry, and are marketed by 3M.

8.3.2 Membrane properties

The irregularity of the pores of most membranes, and the often irregular shape of the particles being filtered, results in there not being a sharp cut-off size during filtration. With symmetric membranes some degree of depth filtration could occur as smaller particles move through the tortuous flow path. To counteract this effect, asymmetric membranes, which have surface pore sizes much less than those in the bulk of the membrane material, are used to trap the particles almost exclusively at one surface (the membrane skin) whilst still offering low hydrodynamic resistance.

A membrane that is *hydrophobic* will have a greater tendency to being fouled, especially by proteins. Hydrophobic membranes require wetting, for example with alcohol, prior to filtration of water-based solutions; they are consequently good filtration media for gases. Three hydrophobic materials commonly used as microfiltration membranes are PTFE, PVDF (polyvinylidenedifluoride) and

polypropylene. These all exhibit excellent to good chemical stability. PTFE is insoluble in most common solvents and is produced by solvent casting. PVDF is less stable than PTFE, and is soluble in aprotic solvents such as dimethylformamide, and can be produced by solvent casting. Polypropylene is the least stable of the three and can be produced by stretching and phase inversion.

Many polymer membrane materials exhibit detrimental adsorption characteristics. Solute adsorption has the effect of reducing flux, and can lead to difficulties in membrane cleaning. *Hydrophilic* membranes are consequently widely used because of their reduced adsorption behaviour. The best-known hydrophilic materials are based on cellulose, such as cellulose ester (acetate, triacetate, nitrate and mixed esters). Cellulose is a polysaccharide, derived from plants, and is quite crystalline; the polymer is very hydrophilic but is not water soluble. Cellulose acetate is a relatively inexpensive hydrophilic material that has good resistance to fouling in many applications, especially with proteins; however, it has a limited pH operating range (3–7), and its operating temperatures need to be below 35°C, while the polymer is very susceptible to biological degradation. Other hydrophilic membranes commonly used are polycarbonate, polysulphone, polyethersulphone and nylon. More recently, ceramic membranes (mainly alumina and zirconia) have become routinely used in more demanding applications. Membranes made from glass, carbon and metals (including silver, aluminium and stainless steel) are used for special applications.

Polysulphone is an engineering polymer used for both microfiltration and ultrafiltration membranes. The ultrafiltration versions are available with a nominal molecular weight cut-off (MWCO) in the range 2–100 kD. Polysulphone exhibits quite good chemical and temperature stability (up to 80°C) and can function in the pH range 1.5–12 for short periods of cleaning. It exhibits some resistance to oxidizing agents (e.g. chlorine) but on prolonged exposure to such materials it will lose its separation characteristics.

PVDF has similar, if not better, pH and temperature tolerances than polysulphone and has a superior tolerance to oxidizing agents and many solvents. It thus can be cleaned with more aggressive agents for substantially longer periods. It is available as an anisotropic membrane, produced by phase inversion.

Polyacrylonitrile is used either alone or as a copolymer, with for example PVC or methyl methacrylate added to increase its hydrophilicity, for ultrafiltration. It offers a tolerance to a wide range of organic solvents.

Semi-crystalline aromatic polyetherketones form an extremely useful range of high-performance engineering polymers, with a unique combination of mechanical toughness, high modulus, hydrolytic stability, resistance to oxidative degradation, the retention of physical properties at moderately high temperatures (up to 250°C), and the ability to withstand organic solvents such as toluene and tetrachloroethylene; these materials are steam sterilizable.

Polyamides are another important class of membranes with good chemical, thermal and mechanical stability. Aliphatic polyamides, such as Nylon-6, Nylon 6-6 and Nylon 4-6, are used as microfiltration and ultrafiltration membranes.

8.4 Membrane Manufacture

Factors that have a profound influence on the structure or morphology of a particular membrane are the nature of the process by which it is manufactured and the form of the raw material used. The various manufacturing processes, which are discussed in this section, can be broadly summarized as:

- sintering of fine graded particles;
- solvent casting or phase inversion, involving the stage-wise evaporation of a solution of polymer in a mixture of solvents;
- irradiation and etching of an impervious film; and
- stretching an impervious film to cause multiple ruptures.

Figures 8.12 and 8.13 respectively provide schematic and photographic representations of the resultant variety of morphologies – strictly speaking for microfiltration membranes only, but actually applying to all kinds.

The manufacturing processes for membranes are actually quite numerous, as shown in Table 8.5. In presenting a brief description of these processes, it is appropriate to distinguish between polymeric membranes, which formerly dominated the whole field, and the increasingly important membranes based on inorganic materials.

8.4.1 Manufacture of polymeric membranes

Polymeric membranes for microfiltration are manufactured by several processes, including stretching, phase inversion (solvent casting) and track etching, as well as sintering. In the case of ultrafiltration membranes, the usual method of preparation is phase inversion, as it is for reverse osmosis and nanofiltration media; ultrafiltration membranes are sometimes used as supports for the production of composite membranes for reverse osmosis and gas permeation.

8.4.1.1 Sintering

The production of membranes by sintering involves the compressing of a powder of particles of carefully graded size, and then heating to an elevated temperature. With the correct temperature of sintering for the specific material, the interface between the particles disappears to produce a porous structure. The pore size produced depends on the particle size and size distribution, but is limited to sizes of 0.1 μm or more. Porosity of the membrane is relatively low, typically in the range 10–20% for polymers (but up to 80% for metal membranes). The method is also used to produce membranes of ceramic, carbon and glass.

8.4.1.2 Stretching

The patented stretching process invented by W L Gore Inc converts impervious PTFE film into a range of membranes. The essence of the process is to subject the hot film to an extremely rapid unidirectional stretching action at about 320°C.

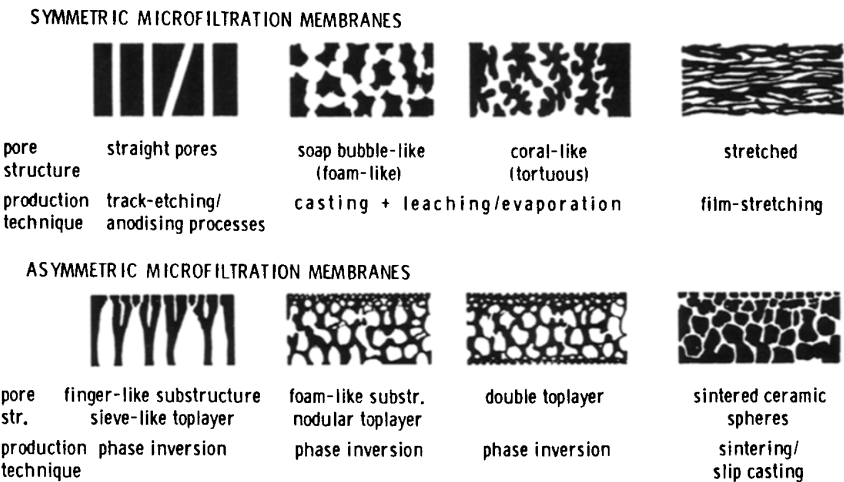


Figure 8.12. Morphologies of microfiltration membranes.

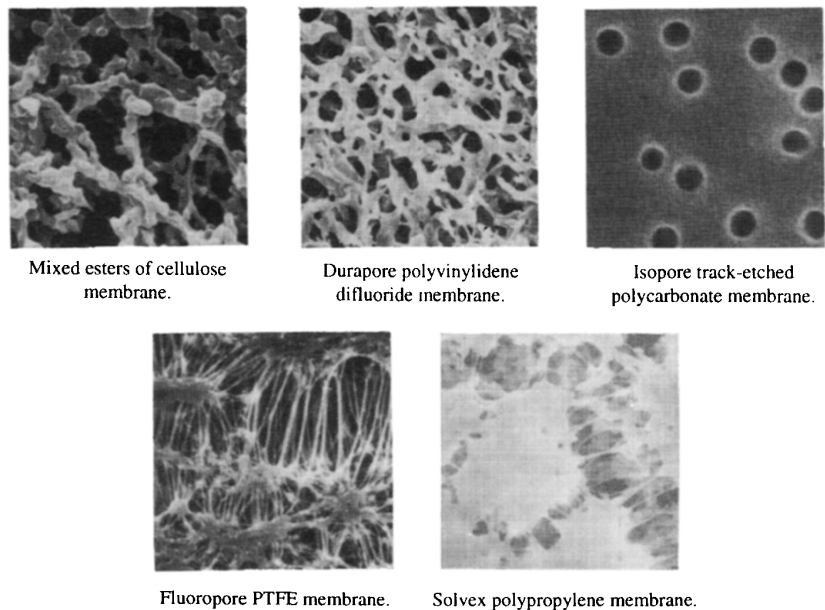


Figure 8.13. Electromicrographs of the surfaces of MF membranes. (Photographs: Millipore Corporation)

Table 8.5 Summary of membrane materials and manufacturing processes

Nominal pore size (μm)	Membrane/ support	Manufacturing process	Module configuration	Mechanical, thermal and chemical stability	Degree of asymmetry
0.1–5	Polysulphone	Immersion precipitation	Hollow fibre	+	++
0.1–0.65	Polypropylene	Thermal precipitation	Hollow fibre/ tubular	++	–
0.1–0.4	Nylon-6		Hollow fibre/ tubular	++	–
0.1	Polysulphone Cellulose acetate Fluoropolymer	Several phase inversion techniques	Hollow fibre/ flat sheet	+	+
			Flat sheet	–	±
			Flat sheet	++	±
2–5	Polyethylene	Phase inversion technique	Tubular	+	–
0.02–0.4	Polypropylene	Stretching	Hollow fibre	++	–
0.1–5	Polysulphone	Immersion precipitation	Flat sheet	+	++
0.1–5	Fluoropolymer		Flat sheet	++	++
0.2–10	Nylon	Evaporation precipitation	Flat sheet	++	–
			cartridge		
0.1–5	Polysulphone	Immersion precipitation	Spiral wound/ tubular	+	+
0.01–0.5	Polyvinylalcohol	Immersion precipitation	Hollow fibre	–	
0.2	Polysulphone/ Fluoropolymer	Phase inversion technique	Flat sheet (rotary module)		
0.2	Polyolefine	Phase inversion technique	Hollow fibre	++	
0.1–0.65	Cellulose nitrate Fluoropolymer	Evaporation/ immersion	Flat sheet	–	±
		Precipitation	Flat sheet	++	±
0.1–1.2	Polysulphone	Immersion precipitation	Spiral wound	+	
	Fluoropolymer		Spiral wound	++	
0.1–1.5	Fluoropolymer	Immersion precipitation	Flat sheet	++	+
0.2–5	Fluoropolymer	Evaporation/ immersion	Flat sheet	++	±
0.6–0.8	Nylon	Precipitation	Flat sheet	++	±
0.05–1	Poly(ether)imide	Immersion precipitation	Hollow fibre/ flat sheet	+	+
0.05–1	Polysulphone		Hollow fibre/ flat sheet	+	+
0.2	Polycarbonate	Track etching	Flat sheet		
0.025–0.2	γ-Al ₂ O ₃	Anodic oxidation	Flat structure	±	–
0.2–5	α-Al ₂ O ₃	Sintering/slip casting	Tubular	+++	++
0.1	ZrO ₂ /α-Al ₂ O ₃		Tubular	+++	

Table 8.5 (continued)

Nominal pore size (μm)	Membrane/support	Manufacturing process	Module configuration	Mechanical, thermal and chemical stability	Degree of asymmetry
0.2–3	Glass	Leaching of soluble phase	Tubular		
0.1	ZrO ₂ /C	Dynamically formed from suspension	Tubular	+	++
0.15–8	SiC	Sintering/slip casting	Tubular	+++	++
0.2–1	Carbon	–	Tubular	+++	++
0.2–1	α-Al ₂ O ₃	Sintering/slip casting	Tubular	+++	++
0.2	SiC	Sintering/slip casting	Tubular	+++	++
0.6–0.14	ZrO ₃ /C	Dynamically formed from suspension	Tubular	++	++
0.05–0.3	Glass	Leaching of soluble phase	Hollow fibre	±	–

followed by a period of heat treatment at a somewhat higher temperature. The first stage generates a structure of small nodes (from less than 1 μm up to 400 μm) connected by a mass of fine fibrils, as shown schematically in Figure 8.14. The heat treatment step results in a change in the crystalline structure, giving what is termed ‘amorphous locking’, with a major increase in mechanical strength. A highly magnified view of a sample of this type of membrane is shown in Figure 8.15.

Whilst the process as summarized permits the direct manufacture of a range of membranes, all of high porosity and strength, their extreme thinness (12–75 μm) presents considerable handling problems. It is essential to combine them with a suitable substrate, so as to give a product that is handleable and robust enough to use. Depending on the intended application, substrates range from lightweight spunbonded polypropylene or polyester, to substantial fabrics, such as thick needlefelts. Figure 8.16 shows a Goretex membrane coating a 500 g/m² needlefelt, at the still higher magnification of ×900. The delicate structure of the membrane is clearly visible, as are the spherical particles of fly ash, their sizes ranging from 3 to 15 μm, trapped on the surface.

8.4.1.3 Track-etching

Track-etched membranes are the closest membrane analogues to a sieve, the membranes being essentially dense polymer films punctuated by cylindrical holes. Figure 8.17 shows the surface of a track-etched membrane, in which the holes are about 0.2 mm in diameter. These membranes are manufactured by a process divided into two steps: tracking and etching. During the tracking phase, a thin polymer film is unrolled at high speed while exposed to a fast-moving beam

of accelerated argon ions. The highly energetic ions pierce the polymer film and break the polymer chains, leaving 'tracks' that are then etched in baths of aggressive chemical agents (such as caustic soda) to convert them into clean, cylindrical pores of a defined uniform character.

The pore density of the membrane is controlled during the tracking step, by modifying the speed of the film, while the pore diameter is controlled during the etching step, by varying the immersion time in the etchant bath. The use of a highly energetic argon ion beam during the tracking step allows the piercing of thicker films than was possible in older processes. The beam of argon ions, accelerated in a cyclotron during the manufacturing, avoids radioactive

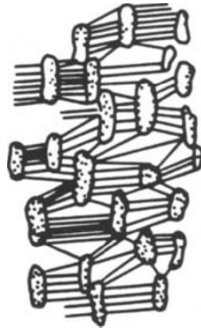


Figure 8.14. Schematic representation of the structure of Goretex membrane (from US Patent 3,953,566)

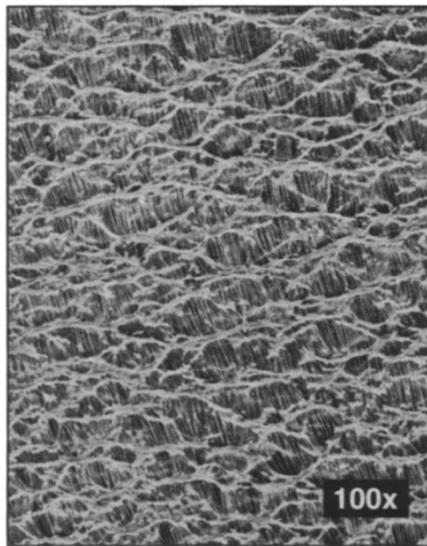


Figure 8.15. A microphotograph of expanded PTFE membrane. (Photograph: Tetratex Corporation)

contamination, and enables the etching to be performed immediately after the tracking step, reducing manufacturing time and improving quality control of the final product.

It has only proved possible to manufacture track-etched membranes with pore sizes in the microfiltration range ($0.03\text{--}8\text{ }\mu\text{m}$). Because these membranes are symmetric, their resistance to the flow of water is proportional to the membrane thickness, and they are therefore made thinner than asymmetric microporous membranes, in order to have comparable fluxes. The usual material that is track

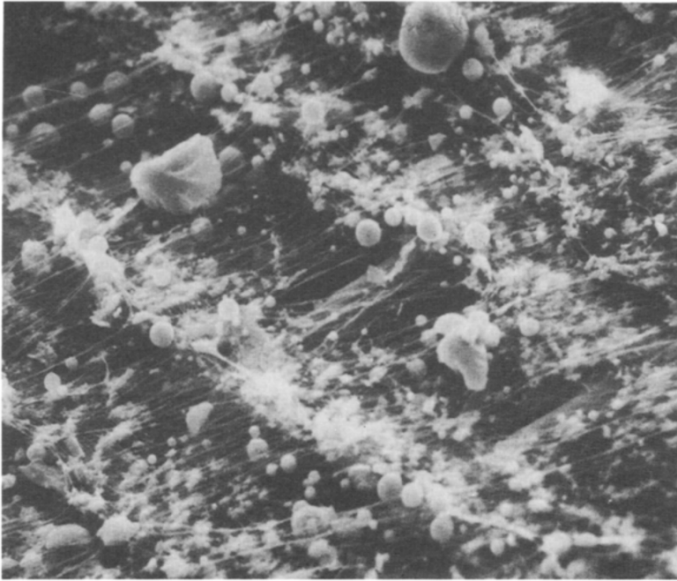


Figure 8.16. Fly ash particles on the Gore-Tex laminated surface of needlefelt.

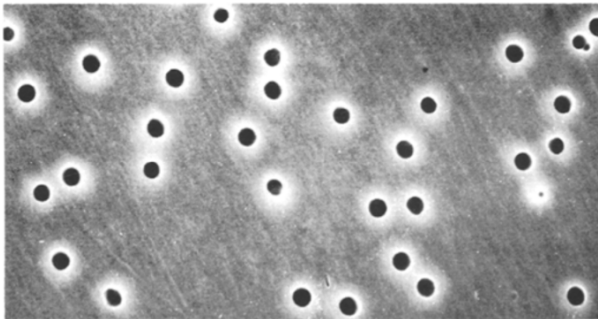


Figure 8.17. Surface of track-etched membrane showing regular hole size and distribution.

etched is polycarbonate, resultant porosities being of the order of 10%, depending on the radiation time.

8.4.1.4 Solvent casting or phase inversion

The majority of polymeric membranes can be produced by a method known variously as solvent casting or phase inversion, whereby a polymer solution inverts into a swollen three-dimensional macromolecular complex or gel. Porous membranes are produced from a two- or three- (or even four-) component dope mixture containing polymer, solvent and non-solvent (and salt in some cases).

The first step is to prepare a casting solution by dissolving polymer in a solvent, which may contain certain additives. To form flat membrane sheets, the casting solution is spread directly onto a suitable support by using a casting knife. The support may be a glass plate or other inert support, from which the membrane is then removed, or a support for the membrane itself (such as a non-woven polyester) to which the membrane remains fixed.

The casting thickness can typically vary from 50 to 500 μm . The cast film is then transferred to a non-solvent (gelation) bath, where exchange occurs between solvent and non-solvent (typically water), which leads to precipitation of the polymer from the solvent.

A typical example of the phase inversion manufacturing process, for cellulose acetate ultrafiltration membranes, is by dissolving the polymer in a mixture of acetone, dioxan and formamide. After precipitation has occurred, a thin skin of polymer forms on the surface of the cast film. The microstructure of the bulk of the membrane is determined in the gelation stage, although the process of gelation is strongly influenced by the properties of the skin at the surface of the membrane exposed to the air.

The invention of this basic process is attributed to Loeb and Sourirajan, an interesting account of whose pioneering work was provided in the opening paper⁽⁸⁾ presented by Loeb to a four-day symposium of the American Chemical Society in 1980. This event was held specifically to mark the 20th anniversary of their development of the first modified asymmetric membranes with commercial potential for reverse osmosis.

Three types of membrane are typically produced in this way:

1. if the skin layer is dense, and has a very high resistance to the gelation medium and the outward transfer of the solvents, the rate of polymer precipitation can be limited by the rate of transfer across the skin, and a uniform porous structure is produced;
2. if the resistance of the skin is such that the rate of diffusion across the bulk of the membrane is more important, a gradation in pore size away from the skin surface is likely to occur, giving an asymmetric sponge-like structure;
3. membranes with finger-like voids are formed if the precipitation of polymer occurs rapidly, i.e. where solvents with little affinity for the polymer are used or where the gelation bath has a high salinity.

The performance characteristics (chiefly flux and selectivity) of phase inversion membranes depend upon many parameters, including polymer concentration, evaporation time before immersion, humidity, temperature,

composition of casting solution, and the composition and condition of the coagulation bath.

Hollow fibre membranes are produced by a different procedure, using various spinning processes (wet spinning, dry-wet spinning, melt spinning and dry spinning). The casting solution is pumped through a spinneret, which is a nozzle with a solid inner annular section that enables the solution to be extruded in a cylindrical form; this spinneret is used for the wet and wet-dry spinning processes. The hollow fibres are self-supporting and demixing occurs both outside and inside the fibre; after spending some time in the air, or in a controlled atmosphere, the fibre is then immersed in a non-solvent coagulation bath.

Tubular polymer membranes require a different procedure since they are not self-supporting. The casting has to be carried out on a supporting tubular material, such as non-woven polyester or carbon.

A variety of other methods for forming membranes by phase inversion are summarized in Table 8.6. Certain polymer membranes cannot be produced by conventional solvent casting because their crystallinity makes them insoluble in conventional solvents at ambient temperatures. This problem can be overcome by thermal phase inversion, in which a polymer is dissolved in a solvent at a high temperature, the solution then being cooled to precipitate the polymer as a formed membrane from which the solvent is removed. Polymeric materials made into membranes in this way include polyethylene, polypropylene, polycarbonate and PVC.

An alternative thermal phase inversion process permits the production of ultrafiltration and microfiltration membranes from aromatic polymers containing in-chain ether or thioether and ketone linkages. Suitable materials are homopolymers such as polyetherketone (PEK) and polyetheretherketone (PEEK), or copolymers such as PEK/PEEK and PEEK/PES (polyethersulphone). The first step is to dissolve the polymer in a 'latent' solvent, which is a compound

Table 8.6 Phase inversion membrane preparation

Precipitation method	Principle
Solvent evaporation	Evaporation on inert support or porous substrate in an inert atmosphere. Produces dense membranes (homogenous).
Vapour phase	Casting of film into a vapour phase of solvent and non-solvent. Membrane formation is due to penetration of non-solvent into cast film, producing a porous membrane with no top layer.
Controlled evaporation	Polymer is dissolved in a solvent/non-solvent mixture. Evaporation of solvent during evaporation shifts the composition to a higher non-solvent and polymer content. This leads to polymer precipitation and the formation of a skin on the membrane.
Thermal precipitation	A polymer and solvent solution is cooled to enable phase separation. Evaporation of solvent can allow the formation of a skinned membrane. Frequently used to prepare microfiltration membranes.
Immersion	A solution of polymer plus solvent is cast (on a support) and immersed in a coagulation bath. Precipitation occurs by the exchange of solvent and non-solvent in the coagulation bath.

in which the polymer is soluble at high temperatures, typically only 5°C below the polymer melting point of 320–340°C, while, at low temperatures, below 100°C, the polymer is only poorly soluble in the chosen solvent. Examples of suitable solvents, with a plurality of aromatic rings, are tetraphenyls, hexaphenyls or polar polyaromatic compounds. The initial concentration of the polymer in the solvent is 10–50 wt.% (preferably 20%); a pore-forming agent (e.g. an inorganic salt or soluble polymer) can be added to the solution. With pore diameters in the range 0.001–1 µm, the membranes manufactured in this way may be asymmetric or isotropic, and either unsupported or supported (e.g. on PTFE, carbon fibre or stainless steel).

Alternative solvents for these otherwise intractable polymers are certain very strong mineral acids, such as liquid hydrogen fluoride, trifluoromethane sulphonic acid and sulphuric acid. Casting solutions can be formed containing, for example, 7–14 wt.% of PEK in 98% sulphuric acid, to produce both flat sheet and hollow fibre membranes for ultrafiltration.

8.4.2 Manufacture of inorganic membranes

There is growing interest in the use of inorganic membranes because of their robustness, their tolerance to extreme conditions of operation, such as higher temperature and aggressive chemicals, and the resultant long life, which offsets their higher initial cost as compared with polymeric membranes. The materials include ceramics, metals, carbon and glass. Some examples are listed in Table 8.7. Inorganic membranes may be homogeneous, asymmetric or composites.

8.4.2.1 Ceramic membranes

Almost all ceramic membranes are made by the sintering of a layer of carefully sized particles. A layer so made would be far too brittle to survive separate use, so

Table 8.7 Range of available porous inorganic membranes

Membrane material	Support material	Membrane pore diameter (nm)	Geometry of membrane element
Ni, Au		> 500	Tube
Ag, Pt			
Ag/Pd		0	Tube
ZrO ₂	C	4	Tube
ZrO ₂	C	4–14	Tube
ZrO ₂	Metal	Dynamic	Tube
ZrO ₂	Al ₂ O ₃	10	Tube
SiC	SiC	150–8000	Tube
SiO ₂ (glass)		4–120	Tube capillary
Al ₂ O ₃	Al ₂ O ₃	4–5000	Monolith/tube
Al ₂ O ₃	Al ₂ O ₃	200–5000	Tube
Al ₂ O ₃	Al ₂ O ₃	200–5000	Tube
Al ₂ O ₃	Al ₂ O ₃	200	Tube
Al ₂ O ₃	Al ₂ O ₃	25–200	Disk

all ceramic membranes are manufactured as a composite structure, with the membrane layer laid down on a porous substrate before sintering.

Composites require a support of open structure, and they may be of ceramics or carbon. For ceramics these supports are typically tubes or monolithic elements with several channels, as in Figure 8.9, fabricated by ceramic shaping methods such as slip-casting, extruding, etc. Carbon supports are typically produced by pyrolysis of a polymeric precursor, or by the pressing of carbon powders or fibres. The supports typically have pore sizes in the range 5–15 μm and porosities of 40–50%, or greater for carbon supports.

Typical use of these supports is to produce microfiltration membranes, which have deposited layers 10–50 μm thick, with pores 0.2–1 μm in size, and 40–50% porosity. The membranes are prepared by film coating the porous support with a suspension of the ceramic powder. The thickness of the coated layer is adjusted by changing the viscosity of the suspension, for example by changing its solids content. In preparation, pinholes in the deposited layer are avoided by suppressing the capillary force effect in the pores. The membrane layer is then formed by sintering at high temperatures, e.g. 1200–1450°C for alumina, the temperature used depending upon material, powder particle size and required pore structure.

The suspensions used in the process are prepared either by milling the powders or, for finer suspensions, by hydrolysis of salts or alkoxides (e.g. those of aluminium, zirconium and silicon). Overall the method is used to apply layers having pore sizes from 0.05 to 0.5 μm and, in the case of zirconia, suspensions on carbon of 0.01 μm pore size. The use of colloidal suspensions is applied in the 'sol-gel' process, which uses the capillary forces in the support to improve adherence between membrane layer and support. The method produces a sharp pore size distribution, with rapid production of layers to 0.01 μm in thickness. In practice the support quality has to be very good and the pore size in the top of the support should be 1 μm or less, otherwise the capillary forces are too weak at the start of the cake filtration/slip casting process. The method can be used to produce membranes with multiple layers, the top layer being the thinnest and with the smallest pore size. Final pore sizes of the order of 0.003 μm can be produced in this way (see Figure 8.18).

The production of crack-free membrane layers requires careful control of the drying, calcining and sintering stages. Drying control agents and organic additives, to adjust viscosity, are frequently employed to adjust the pore size distribution. During calcination and sintering the additives are burnt out. Membranes produced by these methods include alumina and titania layers on ceramics and glass, zirconia on carbon and alumina, and silica on alumina.

Classical slip-casting of slurries or sols on ceramic supports is a common procedure for the preparation of commercial microfiltration and ultrafiltration materials. These materials are manufactured by association of various granular layers. Each ceramic layer is characterized by its thickness, porosity and mean pore diameter, and these parameters are controlled by the particle size and synthesis method. However, the experimental hydraulic resistance of an inorganic composite membrane can be much larger than that obtained by

summing the individual resistances of all the layers. This is explained by the existence of a transition boundary layer between two porous media having drastically different pore sizes.

Non-infiltrated ceramic membranes can provide the expected water permeabilities. To prepare non-infiltrated membranes a new step is introduced, this being pretreatment of the support by impregnating the top of the support material with an aqueous solution of methyl cellulose. After the resulting polymer film has dried, the ceramic suspension is poured into the tube, which is then evacuated for 10 minutes, during which the polymeric dense film prevents any penetration into the pores of the support. The subsequent firing operation destroys the polymeric film and leaves a non-infiltrated membrane. The final temperature and time of firing control the mean pore size and size distribution of the membrane. This process is well suited to the production of titania membranes.

8.4.2.2 Carbon membranes

Carbon membranes, as shown in Figure 8.19, are produced from a thin porous layer of carbon (approximately $0.01\text{ }\mu\text{m}$ thick) applied to the internal surface of a narrow diameter support tube made from a carbon fibre/carbon matrix. The active layer pore size is in a range of $0.1\text{--}1\text{ }\mu\text{m}$. Carbon membranes are particularly useful for operation at very low pH and they can function at temperatures of 165°C and at pressures up to 40 bar. They are suitable for conditions when many cleaning cycles are required either by backflushing or chemically.

8.4.2.3 Porous glass

A technique for preparing porous glass membranes combines leaching with the thermal phase inversion process used for the production of certain types of polymeric membrane. A three-component mixture of the oxides of sodium, boron

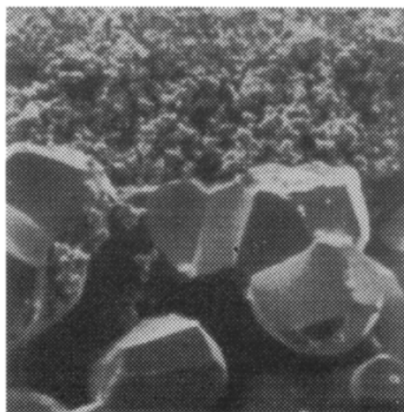


Figure 8.18. Scanning electron micrograph of a ceramic membrane.
(Photograph: APV Membrantechnologie GmbH).

and silicon is converted into a homogeneous melt. When this is cooled it separates into two phases. One phase consists mainly of insoluble silica, while the other phase is soluble. After solidification, the soluble phase is leached out by acid to produce a porous structure.

8.4.2.4 Metal membranes

There is a very indistinct boundary line in any classification of membrane media between ceramic and metal media. Most 'metal' membranes are actually a substrate of metal, with the oxide of that metal, i.e. a ceramic, forming the actual active layer at the surface of the membrane. However, it is customary to regard media that are mainly metal as metal membranes, and they are so discussed here, although there are one or two media that are all metal.

The first of these all metal media is the range of pure metallic *silver membrane* discs available from Osmonics Inc. These are in the form of discs of eight different diameters between 13 and 293 mm, and with particle retention ratings extending from 0.2 to 5 μm . Originally produced by the sintering of silver granules, these membranes are now formed by a reaction bonding mechanism that transforms a suspension of amorphous silver into a strong homogeneous crystalline network of porous silver. The membranes are 50 μm in thickness, with a 60% open area. They are claimed to be usually more economical than disposable filters because they can be reused several times after chemical or ignition cleaning.

Membrane media are also made from *anodized aluminium*. An asymmetric structure that can be formed by anodizing aluminium is shown schematically and photographically in Figure 8.20. The top-side pores have a size of approximately 0.025 μm , while the support pores are of the order of 0.2 μm .

During anodic oxidation, several metals develop coherent porous oxide coatings that adhere strongly to the metal substrate, limiting the direct use of the porous layer as a membrane. For example, anodizing aluminium in electrolytes of oxalic, phosphoric or sulphuric acid, generates a porous structure inwards from the outer surface only as far as an imperforate barrier layer. However, if the voltage of the anodizing cell is varied, say by reducing the starting potential from 25 V to zero in steps of 0.5 V, the resultant pore structure is altered; the single



Figure 8.19. Photomicrograph of a carbon composite membrane showing the fine upper layer and the carbon fibre/composite support. (Photograph: Le Carbone Lorraine)

pores that normally form instead branch into numerous small pores that weaken the film near the substrate metal. Collectively, the branched pore system introduces a weakened stratum into the metal oxide film, thus enabling it to be quite easily separated from the substrate.

The barrier layer is very thin in this process and is generally left on the metal substrate. The detached oxide film is therefore porous on both sides. However, before it is detached from the metal substrate, a perforated supporting layer can be attached to the other side of the film by heat sealing or glue.

An inorganic membrane in the form of an *etched aluminium foil*, as shown in Figure 8.21, may be made from aluminium foil by an etching process that generates a capillary pore structure with a pore size of 0.5–8 μm . Recrystallized aluminium foil is etched, either on both sides to produce a symmetrical pore structure, or on one side to produce an asymmetric structure. The membrane has also been made with a silicon rubber coating, and also with a finer pore size, down to 0.002 μm , produced by coating the pore walls with alumina.

The following typical flow rates for the membrane are reported:

- air – 7000 $\text{m}^3/\text{m}^2/\text{h}$ bar;
- water – 1000–2000 $\text{l}/\text{m}^2/\text{h}$ bar;
- methanol – 2000–3000 $\text{l}/\text{m}^2/\text{h}$ bar.

Advantages claimed for aluminium foil membranes as compared with polymeric or ceramic membranes are:

1. the foil is easily formed; a laser-welded tubular format has been used for standard microfiltration tests;
2. it has excellent resistance to organic solvents, even at elevated temperatures, and to radiation;
3. it is stable in aqueous solution and withstands cleaning by bleaching with oxidizing agents;
4. it is electrically conducting, a property that has been used to obtain flux enhancement in microfiltration, and can facilitate cleaning; and

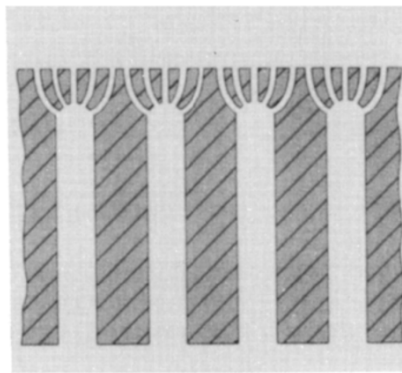
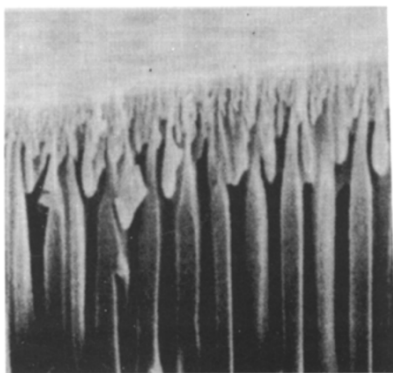


Figure 8.20. Anodized aluminium membrane with asymmetric support. (Photographs: Alcan Int. Ltd)

5. it is tough, withstanding pressures up to 20 bar; this also allows increased filtration rates.

The main metal membrane, however, is that made from *sintered metal*, usually supported on a layer of sintered wire mesh. A simple example of this is Pall's Supramesh Z, data for which are included in Table 6.18 of Chapter 6. It combines a layer of sintered mesh, with a layer of powder or fibre sinter-bonded to the upper surface.

A sophisticated variant of this type of composite metal medium provides the basis for the Pall range of PMM metal membranes. These incorporate a thin sintered matrix of stainless steel or other metal powder within the pore structure of sintered woven wire mesh, as can be seen in the microphotograph of Figure 8.22. These thin, strong and ductile media can be pleated into high specific area packs, while the smooth and highly uniform surface functions as a high-performance medium for filtration down to 2 μm absolute with liquids and 0.4 μm with gases. Some relevant data are given in Table 8.8.

These PMM membrane media are also effective support layers in the highly robust multilayer elements used for filtering molten polymers, where the process conditions combine viscosities up to 4000 poise, temperatures of 250–350°C, and pressure differentials as high as 300 bar.

8.4.2.5 Organo-mineral membranes

Zirfon is a novel form of membrane material described by Leysen⁽⁹⁾, which combines mineral particles with conventional polymeric materials. For example, zirconia particles are combined with polysulphone by dispersing them in the polymer solution used to cast membranes by immersion precipitation in a water bath. The resulting membrane structure consists of a porous polymer network

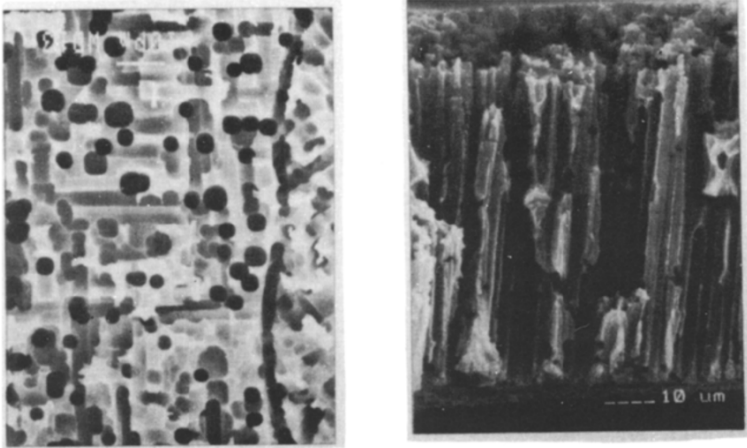


Figure 8.21. Etched aluminium foil membrane: (left) double-sided etched foil; (right) cross-section of the same double-sided etched foil.

incorporating the mineral grains, their presence significantly modifying the resulting membrane structure and the properties of the membrane surface in a very favourable manner. An increase in the weight percentage of zirconia in the casting solution significantly increases the membrane permeability and hence flux; the cut-off values of the membranes are around 25 kD, thus confirming that there are no significant changes in skin pore size.

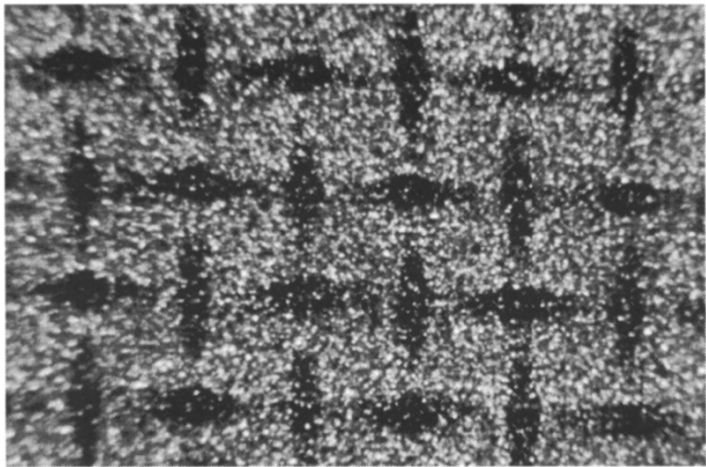


Figure 8.22. Pall 'PMM' filter medium is a sintered composite of mesh and powder.

Table 8.8 Pall PMM sintered mesh and powder media

Media grade	Micron removal rating					Nominal standard thickness (mm)		
	Liquid service ^a			Gas service ^b			Permeability ^c	
	90%	99%	100%	Wt.% removed	100%		to air	to water
M020	0.1	0.5	2	> 99.99	0.4	0.14	4.7	0.07
M050	0.6	2	5	99.99	0.6	0.14	7.6	0.12
M100	2	5	10	99.97	1.3	0.13	10	0.21
M150	5	9	15	99.96	2.5	0.15	31.8	0.35
M200	8	13	20	99.93	4.0	0.23	38.8	0.84
M250	10	16	25	99.90	9.0	0.23	152	2.95

^a Using AC dusts in water, efficiency measured by particle count.
^b Based on AC FineTest Dust in air. Absolute retention rating based on particle count data.
^c l/dm²/min (at 10 mbar pressure drop).

The technology is employed by the Dutch company X-Flow to manufacture hollow fibre membranes for the filtration of potable water and wine. Flat sheet membranes for battery separators are also available.

8.5 Characterization of Membranes

Characterization methods for porous membranes can be divided into two groups of parameters: structure related and permeation related. Certain tests are also used to establish the integrity of membranes in specific applications. The direct measurement of pore statistics is routinely carried out by electron microscopy, as is seen in the various typical SEM (scanning electron microscopy) photographs of membrane structures in this chapter.

Table 8.9 summarizes various test procedures used for microfiltration and ultrafiltration membranes or for filters incorporating these membranes. It should be noted that the asymmetric structure of most ultrafiltration membranes, with top layer pore sizes in the range of 20–1000 Å, means that many of the methods of characterization of microfiltration membranes cannot be applied. Bubble point and mercury intrusion methods require high pressures that would damage or destroy the membrane structure; SEM is generally not possible and TEM (transmission electron microscopy) is not always applicable. The methods that can be used with ultrafiltration membranes include permeation experiments and methods such as gas adsorption–desorption, thermoporometry, permporometry and rejection measurements. The appropriate test methods are discussed in Chapter 11.

Table 8.9 Tests for characterizing membranes or membrane filters

Principle of test	Medium	Characteristic
<i>Microfiltration membranes</i>		
Air diffusion	Air	Integrity
Bubble point test	Air	Pore size
Cartridge retention test	Water	Filtration efficiency
Flow rate vs differential pressure	Water	
Particle shredding test	Water	
TOC tests	Water	
Resistivity test	Water	
Bacteria passage test	<i>Pseudomonas diminuta</i>	Sterility
Mercury intrusion test	Hg	Pore size and pore distribution
Latex sphere test	Latex sphere dispersion	Integrity
Water penetration test	Water	Integrity
Electron microscopy (SEM, TEM)		Pore size, shape, distribution, density
Permeation measurements		Water flux for pore size and distribution.
<i>Ultrafiltration membranes</i>		
Gas adsorption–desorption	N ₂	Pore size and distribution
Thermoporometry	Water	Pore size and distribution
Permporometry	Gas	Pore size and distribution
Solute rejection	Various solutes	MWCO

8.6 Commercial Membranes

The performance of a membrane is defined in terms of two factors, fluid flux and selectivity. Ideally a membrane is required to combine high selectivity with high permeability, but typically attempts to maximize one factor often result in a reduction in the other. Membrane performance characteristics vary considerably from manufacturer to manufacturer, even where comparisons are between nominally identical materials. What follows here is a selection from the very wide range of membrane media available, the selection being made to highlight particular features of the membrane as a filter medium. The emphasis is primarily on microfiltration and ultrafiltration media, with reference to nanofiltration and reverse osmosis membranes only as necessary for completeness.

This part of the first edition's coverage of typical membrane media was divided into separate treatment of micro- and ultrafiltration. These two areas have merged significantly in the time since that edition was prepared, so the coverage now is very largely by material rather than membrane process.

8.6.1 Polymeric membranes

The specifications of Millipore's range of membrane microfilters, with pore sizes in the range 0.025–12 μm , are given in Table 8.10, while their contrasting surfaces are shown in the SEM photographs of Figure 8.13. Within this range it is possible to obtain variants of the basic materials. For example, Durapore PVDF is available as hydrophilic, hydrophobic or super hydrophobic membranes, with radically different protein binding characteristics. The track-etched Isopore polycarbonate membranes are also available in polyethylene terephthalate (PET), which is more resistant to organic solvents.

Certain of these membranes are supplied bonded to a suitable support. The Fluoropore PTFE membranes are laminated to high-density polyethylene to improve handling; however, certain pore grades are available as unsupported materials, where there is a risk of degradation of the support. These are recommended for the filtration of gases and non-aqueous liquids, although a hydrophilic material is available for the filtration of aqueous solutions. Membranes made from polypropylene (for sterilization applications) and PVC (for air monitoring) are also available.

Dead-end microfiltration is primarily carried out with flat sheet membranes, either as discs or rectangular sheets, or in the form of pleated cartridges that can incorporate several square metres of filtration area. Table 8.11 gives specifications for the sheet membranes Millipore provides for use in cross-flow modules of the type illustrated in Figure 8.23. Membranes are available in two materials, Durapore PVDF and Ceraflow, which is a ceramic of α -alumina; each material is available in two grades, a hydrophilic grade for microfiltration and a hydrophobic grade with finer pores for ultrafiltration.

A complete spectrum of membrane media, covering microfiltration to reverse osmosis is supplied by Osmonics, in a catalogue approaching 1000 pages (for

Table 8.10 Specifications of Millipore membranes

Specifications									
Filter type	Mean pore size (μm)	Typical flow rate ^a , water ^b	Typical flow rate ^a , air ^c	Typical porosity (%)	Typical refractive index	Minimum bubble point ^d (bar)	Minimum bubble point ^d (psi)	Autoclavable	Mean thickness (μm)
<i>Durapore (polyvinylidene difluoride)</i>									
SVLP	5.0	288	—	70	1.42	0.21	3	Yes	125
DVPP	0.65	69	—	70	1.42	0.98	14	Yes	125
HVHP	0.45	35	6	75	1.42	0.56	8	Yes	125
HVLP	0.45	29	—	70	1.42	1.55	22	Yes	125
GVHP	0.22	15	3	75	1.42	1.20	17	Yes	125
GVWP	0.22	6.9	—	70	1.42	3.1	45	Yes	125
VVLP	0.10	2.5	—	70	1.42	4.9	70	Yes	125
<i>MF-Millipore (mixed cellulose acetate and nitrate)</i>									
SC	8.0	620	65	84	1.515	0.42	6	Yes	135
SM	5.0	580	32	84	1.495	0.42	6	Yes	135
SS	3.0	320	30	83	1.495	0.70	10	Yes	150
RA	1.2	270	20	82	1.512	0.77	11	Yes	150
AA	0.80	190	16	82	1.510	0.98	14	Yes	150
(black)		190	16	82	—	1.12	16	No	150
DA	0.65	140	9	81	1.510	1.20	17	Yes	150
HA	0.45	60	4	79	1.510	2.11	30	Yes	150
(black)		60	4	79	—	2.32	33	No	180
PH	0.30	32	3	77	1.510	2.46	35	Yes	150
GS	0.22	18	2	75	1.510	3.52	50	Yes	150
VC	0.10	1.5	0.4	74	1.500	14.1	200	Yes	105
VM	0.05	0.74	0.2	72	1.500	17.6	250	Yes	105
VS	0.025	0.15	0.15	70	1.500	21.1	300	Yes	105
<i>Fluoropore (PTFE)</i>									
FS	3.0	286	20	85	^e	0.05	0.7	Yes	200
FA	1.0	90	16	85	^e	0.21	3	Yes	145
FH	0.5	40	8	85	^e	0.49	7	Yes	175
FG	0.2	15	3	70	^e	0.91	13	Yes	175
<i>Miltex (PTFE)</i>									
LC	10.0	126	14	68	—	0.04	0.5	Yes	125
LS	5.0	51.9	9	60	—	0.06	0.9	Yes	125
<i>Isopore (polycarbonate film)</i>									
TM	5.0	2000	50	—	1.6	0.21	3	Yes	10
TS	3.0	1500	50	—	1.6	0.42	5	Yes	9
TT	2.0	350	22	—	1.6	0.63	9	Yes	10
RT	1.2	250	20	—	1.6	0.77	11	Yes	11

Table 8.10 (continued)

Specifications								
Filter type	Mean pore size (µm)	Typical flow rate ^a , water ^b	Typical flow rate ^a , air ^c	Typical porosity (%)	Typical refractive index	Minimum bubble point ^d (bar)	Minimum bubble point ^d (psi)	Autoclavable
AT	0.8	215	20	–	1.6	1.3	18	Yes
DT	0.6	115	10	–	1.6	1.7	24	Yes
HT	0.4	70	10	–	1.6	2.5	35	Yes
GT	0.2	7	1	–	1.6	5.3	75	Yes

^aFlow rates listed are based on measurements with clean water and air, and represent initial flow rates for a liquid of 1 centipoise viscosity at the start of filtration, before filter plugging is detectable. Actual initial flow rates may vary from the average values given here.

^bWater flow rates are millilitres per minute per cm² of filtration area, at 200°C with a differential pressure of 0.7 bar (10 psi). Flow rates for Fluoropore, Durapore hydrophobic and Miltex filters are based on methanol instead of water.

^cAir flow rates are litres per minute per cm² of filtration area, at 20°C with a differential pressure of 0.7 bar (10 psi) and exit pressure of 1 atmosphere (14.7 psia).

^dBubble point pressure is the differential pressure required to force air through the pores of a water-wet filter (except methanol-wet for Fluoropore, hydrophobic Durapore and Miltex filters).

^eCrystalline and amorphous regions of Fluoropore filters have differing refractive indices, and it is therefore not possible to obtain uniform clearing.

Additional notes: Flow rate correction for viscosity: For a liquid having a viscosity significantly different from that of water (1 cps), divide the water flow rate by the viscosity of the liquid in centipoises to obtain the approximate initial flow rate for the liquid in question (viscosity of methanol is 0.6 cps at 20°C).
Water Extractables: Water extractables measure 5% or less for most filter types, except for Durapore membranes, which measure 0.5%.

systems as well as elements and components). The microfiltration media are marketed under the Desal brand name, as spiral wound units, in three ranges, all safe up to 50°C:

- E500 Series: cut-off size 0.04 µm, made from polysulphone.

EW4026F	5.6 m ² filter area	24.6 m ³ /day flow at 207 kPa & 25°C
EW4040F	8.4 m ²	41.6 m ³ /day
EW8040F	32.5 m ²	136.1 m ³ /day

- J Series: cut-off size 0.3 µm, made from PVDF.

JX4040F	8.4 m ² filter area	45.4 m ³ /day flow at 207 kPa & 25°C
JX8040F	32.5 m ²	151.0 m ³ /day

- K Series: cut-off sizes 0.1, 0.2, 0.5, 1.0 and 3.0 μm , made from PTFE.

K2540	1.2 m ² filter area
K4040	4.7 m ²
K8040	18.6 m ²

Table 8.11 Millipore membranes for MF and UF cross-flow filtration

Specification	Durapore	Ceraflo	PZHK	Ceraflo-UF
Material	Hydrophilic PVDF	α -Alumina with Teflon end seal	Hydrophobic PVDF	α -Alumina with Teflon end seal
Pore sizes (μm)	0.10 0.22 0.45	0.20 0.45 1.00	0.04 (approx.)	0.02 (approx.)
NMWL (kDalton)			200	50
Tested by	Bubble point	Bubble point	Dextran retention	Dextran retention
<i>Properties</i>				
Temperature	4–135°C	–100–150°C	4–135°C	–100–150°C
Max. pressure (25°C)	6 bar	10 bar	6 bar	10 bar
Continuous	2–10	0–14	2–12	4–10 (> 50°C)
Intermittent	1–13	0–14	1–13	4–10 (> 50°C)
Organic solvent compatibility	Limited	Broad	Limited	Broad
Protein binding	Very low	High	Medium	High
Biocompatibility USP test	Pass	n/a	Pass	n/a
Abrasion resistance	Poor	Excellent	Poor	Excellent

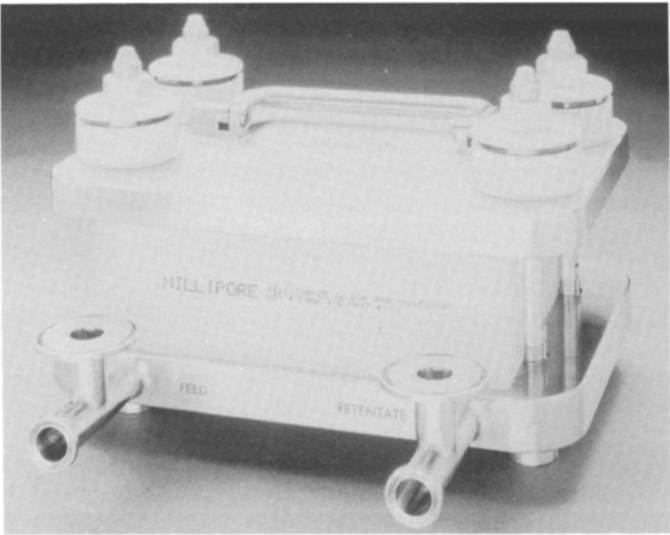


Figure 8.23. A ‘Pellicon’ cassette holder for cross-flow filtration. (Photograph: Millipore Corporation)

Whatman's ranges of track-etched microfiltration media are sold under the Nuclepore and Cyclopore brand names. Cyclopore in polycarbonate and polyester. Nuclepore in polycarbonate and mixed cellulose esters (CA and CN). Typical flux data and other values are given in Table 8.12 for the Nuclepore media. Cyclopore has a similar range of pore sizes (0.1–12 µm) and is slightly thicker (8–20 µm). Values of flux decrease with pore size and there is a corresponding increase in the bubble point pressures.

Common polymeric materials used for ultrafiltration membranes are regenerated cellulose and polysulphone or polyethersulphone, which are available in a range of molecular weight cut-off values, as illustrated by Millipore's media in Table 8.13.

Membrane area data for ultrafiltration hollow fibre cartridge units with polysulphone membranes are given in Table 8.14. These membranes have internal diameters between 0.5 and 1.5 µm and are free from macrovoids. For pure water, the cross-flow velocity will have little, if any, effect on flux. However, this is not the case with real process fluids, where the build-up of solutes at the membrane surface induces concentration polarization that reduces the flux.

The performance of an ultrafiltration membrane is defined in terms of its ability to retain molecules of a specific size, i.e. a rejection factor *R*, which is expressed as a number between 0 and 1 (or sometimes as a percentage). Values of rejection are not absolute values for any single membrane or solution, but depend upon conditions of operation, the concentration of the feed solution, the

Table 8.12 Track etched 'Nuclepore' microfiltration membranes^d

Rated pore size (µm)	Rated pore density (pores/cm ²)	Nominal wt. (mg/cm ²)	Nominal thickness (µm)	Bubble point ^c		Typical flow rates	
				psi	bar	Water ^a (ml/min/cm ²)	Air (l/min/cm ²)
12.0	1×10 ⁵	1.0	8	< 1	> 0.07	3000	85 ^b
10.0	1×10 ⁵	1.0	10	> 1	> 0.07	2500	65 ^b
8.0	1×10 ⁵	1.0	7	3	0.21	2000	40 ^b
5.0	4×10 ⁵	1.0	10	3	0.21	2000	55 ^b
3.0	2×10 ⁶	1.0	9	7	0.48	1500	50 ^b
2.0	2×10 ⁶	1.0	10	9	0.62	350	22
1.0	2×10 ⁷	1.0	11	14	0.96	250	25
0.8	3×10 ⁷	1.0	9	18	1.24	215	24
0.6	3×10 ⁷	1.0	10	29	2.00	115	10
0.4	1×10 ⁸	1.0	10	42	2.90	70	11
0.2	3×10 ⁸	1.0	10	82	2.65	20	4.0
0.1	3×10 ⁸	0.6	6	> 100	> 6.90	4.0	1.5
0.05	6×10 ⁸	0.6	6	> 100	> 6.90	0.7	0.70
0.015	6×10 ⁸	0.6	6	> 100	> 6.90	< 0.01	0.024

^a Typical flow rate using water or air at 10 psi (0.7 bar).

^b 5 psi (0.35 bar).

^c Water bubble point.

^d Whatman International Ltd.

flow rate and the extent of concentration polarization at the membrane surface. Rejection coefficients vary with the molar mass of the solute, as shown in Figure 8.24 for the ultrafiltration of dextran and with the membranes of Table 8.13. The use of polydisperse dextran solutions is claimed to be a better retention test marker than single-protein solutions, to ensure quality control of the rejection performance.

The tubular membranes illustrated in Figure 8.7 are the basis for PCI Memtech's range of RO, NF and UF separation systems, which have now been extended to cover microfiltration, while the types supplied now include spiral wound modules as well as ceramic tubes. There are 22 items in the tubular membrane range, covering reverse osmosis, nano- and ultrafiltration, and 9 items in the spiral wound list.

An ultrafiltration specialist, Koch Membrane Systems, has, for just industrial water and wastewater treatment, 10 different systems, all covering cut-off figures of 50–120 kD. There are three tubular formats, in PVDF, four hollow fibre formats, variously in PAN and polysulphone, and three spiral wound, also in PVDF.

A/G Technology is a hollow fibre specialist, providing membranes and membrane systems for microfiltration and ultrafiltration. The microfiltration cartridges have pore cut-off sizes of 0.1, 0.2, 0.45 and 0.65 μm , while the ultrafiltration cartridges have nominal molecular weight cut-off (NMWC) values of 1000–750 000. Membrane areas run from less than 0.01–28 m^2 .

Table 8.13 Millipore membranes for ultrafiltration^b

Specifications	PL series	PT series
Material	Regenerated cellulose on polypropylene	Polyethersulphone on polypropylene
	NMWL (kD)	1 PLAC
	3 PLBC	
	5 PLCC	10 PTGC
	10 PLGC	30 PTTK
	30 PLTK	50 PTQK
	100 PLHK	100 PTHK
	300 PLMK	300 PTMK
Retention specifications	See Figure 8.24	See Figure 8.24
<i>Properties</i>		
Temperature	4–50°C	4–50°C
Maximum pressure	7 bar	7 bar
pH range (25°C)		
Continuous	2–12	1–14
Intermittent (e.g. cleaning)	2–13	1–14
Organic solvent compatibility	Broad ^a	Limited
Protein binding	Very low	High
Susceptibility to antifoam fouling	Low	High

^a In Prostack-UF modules only.

^b Millipore Corporation.

Table 8.14 Membrane area values for UF polysulphone membranes

Membrane area as a function of housing and fibre/tubule internal diameter				
Cartridge housing identifier	Fibre/tubule internal diameter code	Fibre/tubule internal diameter (mm)	Cartridge membrane area	
			sq. ft	sq. m
3	C	0.5	0.16	0.015
	D	0.75	0.10	0.009
	E	1	0.08	0.007
4	C	0.5	0.70	0.065
	D	0.75	0.50	0.046
	E	1	0.35	0.032
4X2TC	H	2	0.8	0.073
	K	3	0.5	0.046
5	C	0.5	3	0.28
	D	0.75	2	0.19
	E	1	1.5	0.14
6	C	0.5	6	0.56
	D	0.75	4	0.37
	E	1	3	0.28
	H	2	2.4	0.22
	K	3	1.6	0.15
8	C	0.5	6.7	0.62
	D	0.75	5	0.46
	E	1	3.75	0.35
9	C	0.5	15	1.4
	D	0.75	10	0.93
	E	1	7.5	0.7
	H	2	6	0.55
	K	3	4.9	0.45
10	H	2	12.1	1.1
	K	3	8.8	0.82
35, 35A 35STM	C	0.5	14	1.3
	D	0.75	11	1
	E	1	8.5	0.8
55, 55A 55R, 55STM	C	0.5	36	3.4
	D	0.75	27	2.5
	E	1	23	2.1
	H	2	14	1.3
	K	3	10.6	1
75, 75R	C	0.5	65	6
	E	1	40	3.7
	H	2	27	2.5
	K	3	20	2

Aided by the well-known non-stick properties of PTFE, the membranes made from ePTFE have proved to be highly successful, especially for use in fabric dust filters, using all kinds of cleaning mechanism: shaker, reverse flow or pulse jet. Versions are available utilizing a variety of substrate materials to suit different operating temperatures, as illustrated by the Tetratex media of Tables 8.15 and 8.16.

The use of ePTFE laminated fabrics in dust filters is beneficial by comparison with conventional fabrics in terms of air/cloth ratio (flow per unit area), pressure drop, bag life, and lower dust emission values. Several case histories are summarized in Table 8.17.

W L Gore, the originators of ePTFE, has recently introduced a new form of Gore-Tex ePTFE membrane, which, laid on a polyester needlefelt, is being marketed as a High Durability filter bag. The company also has a membrane medium offering catalytic destruction of dioxins and furans, and has established the Pristyne brand name for a series of filter bags using ePTFE membranes on substrates made from seven different fibres, as felts, wovens or spunbonds.

Dow is one of the largest membrane material makers in the world, largely for the reverse osmosis market, under the Filmtec brand name. Data for water treatment using these polyamide membranes are given in Table 8.18.

8.6.2 Inorganic membranes

In high-temperature processes with hot aggressive fluids, filtration requirements can only be met by a limited number of materials. Carbon is one such material well known for its corrosion resistance. Membranes made from carbon are typically a composite structure of a very thin layer of porous carbon applied to the internal surface of a narrow diameter carbon fibre/composite support tube. The membrane tubes are assembled in monolithic joint-free bundles (see Figure 8.25) using a carbon composite tube sheet. The bundles are then mounted in a shell made from an appropriate compatible material such as PTFE-lined steel or stainless steel. The carbon tubes are 6 mm internal diameter and 1.5 mm thick, giving good mechanical resistance, i.e. bursting pressures of 40 bar.

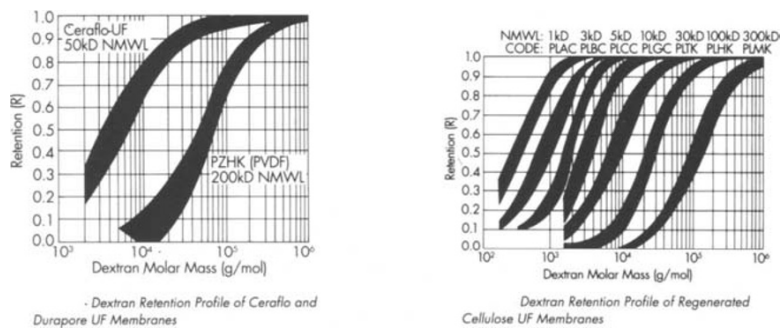


Figure 8.24. Rejection characteristics of the UF membranes in Tables 8.11 and 8.13.

Table 8.15 'Tetratex' PTFE membrane/needle felt laminates^a

Product code	6202	6211	6212	6222	6272	6232	6242	6262
Fibre	PE	PE	PE	PP	PE _{gallotropic}	P-84	Nomex	Ryton
Scrim	PE	None	PE	PP	PE	P-84	Nomex	Ryton
Weight (g/m ²)	400-490	510-590	510-590	490-560	440-520	440-520	440-520	510-560
Thickness (mm ± 0.25)	1.1	1.5	1.5	1.8	1.3	2.3	1.4	1.5
Width (mm ± 12.5)	1690	1690	1690	1690	1690	1730	1730	1690
Air permeability (l/dm ² /min @ 20 mm WG)	39-54	39-54	39-54	39-54	39-54	39-54	39-54	39-54
Continuous service temperature (°C)	135	135	135	120	135	245	205	190
Minimum Mullen burst pressure (kg/cm ²)	25	32	32	35	32	25	28	28
Minimum breaking strength (kg/5 cm)								
Machine direction	27	34	34	36	34	67	54	45
Across machine	54	67	67	45	67	101	76	45
Maximum elongation (% @ 2.3 kg/5 cm)								
Machine direction	10	8	8	8	10	n/a	n/a	8
Across machine	10	8	8	8	10	n/a	n/a	8
Maximum % unrestricted shrinkage in 24 h, dry heat @ specified °C	3	3	3	3	3	1.5	2	3
	177	177	177	105	177	1 h @ 245	1 h @ 230	1 h @ 205

^a Donaldson Tetratex.

This carbon tube module has a great tolerance to the many thousands of back flushing operations at 8–12 bar typically used to clean the membrane of fouling layers *in situ*. Sealing of the bundles into the end plates ensures no bypass problems. The membranes are tolerant to strong acids at all concentrations, hot organic solvents and alkaline baths, but not to strong oxidizing agents. Carbon is a fully biocompatible material, recommended for alimentary and other biological fluids.

In recent years, there has been substantial development of ceramic membranes, with specific features of heat resistance, a high degree of resistance to organic solvents, good cleaning potential, high mechanical strength, applicable in a wide pH range, a long life cycle and a good price/performance ratio. Modules are supplied in a wide range of sizes to meet most applications of microfiltration with a pore size of 0.1–5 μm . The filtration systems are constructed as cylinders equipped with ceramic filtration tubes. The disadvantages of ceramic membranes compared to polymeric membranes are that they are brittle, the surface area/volume ratio is lower and the cost is relatively high.

Typical characteristics of ceramic membranes are shown in Table 8.19. Ceramic ultrafiltration membranes can be constructed in several layers, by successively depositing finer layers of α - and γ -alumina onto a ceramics support tube of high porosity. The top layer is the real membrane layer and is responsible for the separation; it needs to be very thin to achieve a high flux. Sizes start from a membrane area of 0.05 m^2 with typical filtration flows of 3–9 dm^3/h , up to a membrane area of 4 m^2 at filtration flows of 175–500 dm^3/h . The configuration is based on a porous hexagonal log into which a series of 4 mm diameter channels are introduced. The elements are either single- or 19-channel design, with the latter giving a 0.2 m^2 internal filtration surface for a 900 mm long, 25 mm diameter unit. The operating range of pH is 1–11 at 700°C and 1–14 at 250°C. For microfiltration the pore size cut-off sizes can vary from 0.05 to 10 μm . Typical water fluxes are shown in Figure 8.26 for microfiltration membranes.

Table 8.16 'Tetratex' PTFE membrane/woven glass laminates^a

Product code	6254	6253	6252	6255
Average weight (g/m^2)	305	475	543	760
Actual weight (g/m^2)	322–373	458–526	543–627	712–814
Width ($\text{mm} \pm 12.5$)	978	978	1650	1650
BGF style no.	427	454	448	477
Finish style no.	615	615	615	615
JPS style no.	3602	651	648	7577
Finish style no.	Teflon B	Teflon B	Teflon B	Teflon B
Air permeability ($\text{l}/\text{dm}^2/\text{min}$ @ 20 mm WG)	34–44	29–39	24–34	29–39
Continuous service temperature ($^{\circ}\text{C}$)	260	260	260	260
Minimum Mullen burst pressure (kg/cm^2) ²	35	42	42	63
Minimum tensile strength ($\text{kg}/5 \text{ cm}$)				
Machine direction	260	450	270	450
Across machine	144	225	225	315

^a Donaldson Tetratex.

Table 8.17 Case histories demonstrating benefits of PTFE laminates for dust filters^a

Dust:	PVC		Lead oxide		Sugar		Boiler flyash		Cement	
System:	Spray dryer		Processing		Silo exhaust		Exhaust gases		Crusher venting	
Filter type:	Reverse air		Shaker		Pulse jet		Shaker		Reverse air + shaker	
Filter media:	Acrylic		Dacron		GoreTex		GoreTex		Polyester felt	
Air/cloth ratio	2/1	3.6/1	1.5/1	3/1	10/1	10/1	7/1	7/1	5/1	5/1
Gas flow (m ³ /min)	840	1540	616	1232	NA	22	NA	294	NA	266
Pressure loss (mm WG)	279	51	76	76	254	25	203	102	178	64
Bag life (months)	6	24	1.2	26	1/2	1.2	3	15	6	17
Comments	^b		^c		Visible plume		No plume visible		5 µm dust	

^a W.L. Gore & Associates, Inc.
^b Up to 75% increase in production rate (kg/h).
^c At A/C ratio of 3/1, pressure loss > 300 mm WG.

The LCI Corporation sells what is basically a stainless steel tubular microfiltration system, which has a fine sintered TiO_2 membrane on a stainless steel support. For ultrafiltration, a ceramic membrane is laid on top of the titania, and for nanofiltration, a synthetic polymer membrane is laid on top of the ceramic one. The resultant separations achieved run from 1 μm down to 0.001 μm .

A fully metallic membrane is offered by GKN Sinter Metal Filters, in the form of its SIKA-R. . . AS medium. This involves powder metal technology to produce a base of coarse metal powder, and a thin layer (200 μm) of the same alloy diffusion bonded to it, during the sintering process. Operation up to 900°C in an oxidizing atmosphere is possible⁽¹⁰⁾, with efficient removal of dust particles in the 0/5–10 μm range.

8.7 Guidance on Membrane Selection

The performance and selection of a membrane is affected by a multiplicity of factors associated with the membrane medium, the particulate material, the fluid carrier phase, the conditions of operation, and the interactions among all these

Table 8.18 Filmtec nanofiltration membranes^e

Grade	Diameter ^a	Area ^b	Flow ^c	Rejection ^d
NF90-2540	61	2.6	2.3	99.0 (Mg SO ₄)
NF90-4040	99	7.6	7.0	99.0 (Mg SO ₄)
NF90-400	201	37.2	28.4	85–95 (NaCl)
NF200-400	201	37.2	30.3	35–50 (CaCl ₂)
NF270-400	201	37.2	55.6	40–60 (CaCl ₂)
NF270-2540	61	2.6	3.2	99.0 (Mg SO ₄)
NF270-4040	99	7.6	9.5	99.0 (Mg SO ₄)
NF400	201	37.2	25.7	98.0 (Mg SO ₄)

^a Element diameter (mm) for 1016 mm length.

^b Separation area (m²).

^c Water flow (m³/day).

^d Stabilized flow rejection (%).

^e The Dow Chemical Company.

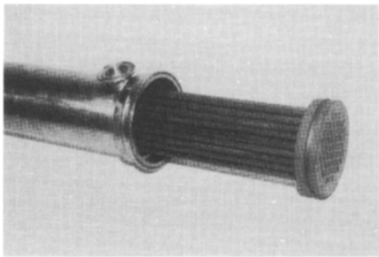


Figure 8.25. Carbon fibre cross-flow filtration module.

Table 8.19 Characteristics of ceramic membranes

Product characteristics	Microfilter	Ultrafilter	Ultrafilter
Membrane composition	Alpha Alumina	Gamma Alumina	Zirconia Alumina
Available pore size	0.2–5 µm	50–1000 Å	200–1000 Å
Burst pressure	Limited by the maximum housing operating pressure		
Maximum operating pressure	120 psig (standard, higher pressures optional)	120 psig (standard, higher pressures optional)	120 psig (standard, higher pressures optional)
Water permeability 20°C			
0.2 µm pore Ø	2000 l/h m ² bar		
40 Å pore Ø		10 l/h m ² bar	
500 Å pore Ø			850 l/h m ² bar
Resistance to corrosion	Can be washed with NaOCl 2% NaOH 2% HNO ₃	Limited	Same as Microfilter
Steam sterilizable ^a	Yes	Yes	Yes

^a The Membralox Steam Sterilization Procedure must be followed.

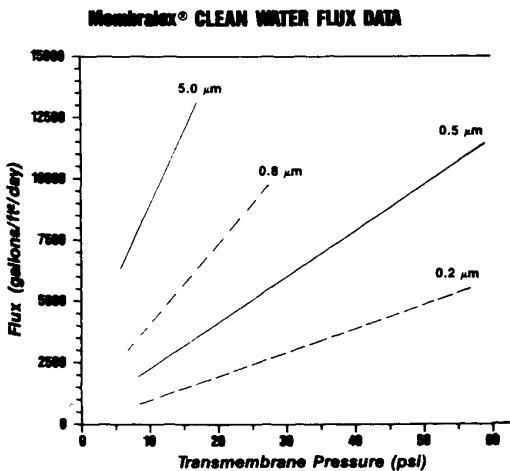


Figure 8.26. Typical clean water flux/pressure curves for ceramic membranes.

factors. Of particular importance are those that relate to the particulate material (size, shape, concentration, distribution, zeta potential, and whether it is inert or viable), the membrane structure (pore size, rating, asymmetry), the stability of the membrane (chemical, mechanical, thermal, hydrolytic, extractables, shedding), and the retention mechanisms (absorption, adsorption, impingement, cake retention).

The selection of an optimum (or at least an appropriate) membrane and system will usually require a trade-off between various possible alternatives. Table 8.20 summarizes the typical information required to permit a systematic analysis of the available options.

The important performance indicator in microfiltration is the volumetric flow through the membrane, which is directly proportional to the applied pressure difference across it. For most membranes, values of fluid flux are quoted for particular conditions of temperature and applied pressure, with specific fluids, which typically are water, air and methanol.

From the data normally available for membranes, it is possible to calculate the permeability constant for the membrane for a particular fluid. In principle, this should be independent of the fluid if there are no interactions between the membrane and the feed slurry. The important factor in microfiltration is not the flux of clean fluid but the performance during actual filtration. Performance is potentially affected by several solute-related parameters and specifically by concentration polarization and fouling.

A good general review of microfiltration is given in Table 8.21. This was produced originally by Costar, but is still generally applicable.

Microfiltration membranes are routinely used in a range of analytical procedures to determine particulate contamination in a wide range of gases and liquids. The procedures include the detection of micro-organisms in a variety of waters and process fluids (foods, beverages, pharmaceuticals) where the membrane traps the micro-organism and is subsequently used as the culture medium, in passive cell growth studies and in so-called blotting applications. A range of different types of membrane is used, including:

1. mixed cellulose esters – e.g. biologically inert mixtures of cellulose acetate and cellulose nitrate; suitable for a wide range of analytical procedures, including gravimetric analysis by the ashing technique and light microscopy;
2. PTFE – either unlaminated or laminated to a support of high-density polyethylene or polypropylene; for applications with gases and non-aqueous fluids, with acids and alkalis, and for higher temperature operation;
3. silver – ideal collection medium for analysis of crystalline silica by X-ray diffusion and for the analysis of organics;
4. PVDF – suitable for aqueous or organic samples; and
5. track-etched polycarbonate – recommended for scanning and transmission electron microscopy.

Commercial polymeric ultrafiltration membranes are designed to give the requirement of high permeability and high permselectivity. An extensive range of membrane materials is used including polysulphone, polyethersulphone, PAN, polyimide, cellulose acetate, aliphatic polyamides, the oxides of zirconium

Table 8.20 Membrane filtration selection criteria

Criteria	Characteristics
Fluid properties	<p>What liquid or gas is being filtered?</p> <p>What are the fluid properties (pH, viscosity, temperature, surface tension, stability, etc.)?</p> <p>What are the important chemical components and their concentrations?</p> <p>What pretreatment has been given to fluid?</p> <p>What is the desired minimum and maximum flow rate?</p> <p>What is the product batch size?</p>
Pressure characteristics	<p>What is the maximum inlet pressure?</p> <p>What is the maximum allowable differential pressure?</p> <p>Is there a required initial differential pressure?</p> <p>What is the source of pressure (centrifugal/positive displacement pump, gravity, vacuum, compressed gas, etc.)?</p>
Sterilization/sanitization	<p>Will the filtration system be steamed or autoclaved?</p> <p>Will the system be sanitized with chemicals or hot water?</p> <p>How many times will the system be sterilized or sanitized?</p> <p>What are the sterilized/sanitized conditions?</p>
Hardware	<p>Is there a restriction on the material for the housing?</p> <p>Is there a recommended housing surface finish?</p> <p>What are the inlet and outlet plumbing connections?</p> <p>Is there a size or weight restriction?</p>
Filter	<p>What is the size of particles to be retained?</p> <p>Will the filter be integrity tested; if so, how?</p> <p>Will this be a sterilizing filtration?</p> <p>Is there a minimum acceptable level of particle removal?</p> <p>Is there a recommended filter change frequency?</p>
Temperature	<p>What is the temperature of the fluid? Temperature affects the viscosity of liquids, the volume of gases and the compatibility of the filtration system.</p>
Configuration	<p>How will the filtration systems be configured – in series or in parallel?</p> <p><i>Parallel flow arrangement:</i> uses several filters of equal pore size simultaneously to either increase flow rates, extend filter service life or lower differential pressure. It also permits filter changeout without system shutdown. The total flow rate and differential pressure is equally distributed across each filter. For any given flow rate, the differential pressure can be reduced by increasing the number of filters in parallel.</p> <p><i>Series flow arrangement:</i> uses a group of filters of descending pore sizes to protect the final filter when the contaminant size distribution indicates a wide range or a high level of particulates that are larger than the final pore size. You can also use additional filters of the same pore size in series to improve particle removal efficiency, to protect against the possible failure of a unit within the system, and to add an extra measure of safety in any application.</p>

Table 8.21 Guidance on membrane applications

Application	Recommended filter media			References/comments
	Description	Pore size (µm)	Diameter (mm)	
<i>Air pollution analysis</i>				
Asbestos, airborne	Mixed esters of cellulose	0.45, 0.8, 1.2	25	NIOSH Methods 7400 and 7402; EPA-CFR 76.3-Fed Reg. 1987, pp. 41826–41905.
Cadmium	Mixed-esters of cellulose	0.8	37	NIOSH Method 7048
Carbon black	PVC	5.0	37	NIOSH Method 5000
Cyanides	Mixed-esters of cellulose	0.8	37	NIOSH Method 7904
Lead	Mixed-esters of cellulose	0.8	37	NIOSH Method 7082
Lead sulphide	PVC	5.0	37	NIOSH Method 7505
Nuisance dust	PVC	5.0	37	NIOSH Methods 0500 and 0600
Quartz in coal dust	Mixed-esters of cellulose	0.8	37	NIOSH Method 7602
Silica, crystalline	PVC	5.0	37	NIOSH Method 7601
Welding and brazing fume	Mixed-esters of cellulose	0.8	37	NIOSH Method 7200
Zinc oxide	PVC	0.8	25	NIOSH Method 7502
Trace elements	Polycarbonate aerosol-type	0.2–8.0	25–47, 8 × 10 in	Low trace metal contamination (Br, Pb, Zn, etc.) with aerosol holders
<i>Bacterial Analysis</i>				
Total coliform count	Mixed-esters of cellulose	0.45	47	<i>Standard Methods/Water & Wastewater</i> , 17th Ed., 9222B
Fecal coliform	Mixed-esters of cellulose	0.7	47	<i>Standard Methods/Water & Wastewater</i> 17th Ed., 9221
Legionella	Polycarbonate	0.2	37, 47	
Heterotrophic plate count (HPC) (formally known as standard plate count)	Mixed-esters of cellulose	0.45	47	<i>Standard Methods/Water & Wastewater</i> , 17th Ed., 9215D
Direct total microbial count	Polycarbonate	0.2	25	<i>Standard Methods/Water & Wastewater</i> , 17th Ed., 9216B
	Mixed-esters of cellulose	5.0	25	
<i>Escherichia coli</i>	Mixed-esters of cellulose	0.45	85	For <i>E. coli</i> , use REC-85 [®] food micro membrane, direct plating technique in petri dish
Yeast and moulds	Mixed-esters of cellulose	0.65–1.2	13–47	
	Polycarbonate	0.6, 0.8	13–47	

Table 8.21 (continued)

Application	Recommended filter media			References/comments
	Description	Pore size (μm)	Diameter (mm)	
Sterility testing	Mixed-esters of cellulose	0.22, 0.45	47	For sterility testing, use gridded, sterile hydrophobic edge membranes (see <i>Code of Federal Regulations</i> , Title 21 #436)
<i>Blood filtration</i>				
RBC deformability	Polycarbonate Hema-Fil	4.7–5.0	13, 25	
Plasmapheresis	Polycarbonate	0.6–1.0	90	Use fluid cross-flow, thin channel technique
Cell culture	Polycarbonate	0.4–3.0	13–47	Fit membrane to petri dish or culture plate
<i>Chemotaxis</i>				
Epithelial, fibroblasts, neutrophils, polymorpho-nuclear leukocytes	Polycarbonate (chemotaxis membrane, PVP-free)	2.0–8.0	13	For chemotaxis, use blind well or modified Boyden chambers
Macrophage	Polycarbonate (chemotaxis membrane)	2.0–8.0	13	
<i>Cytology</i>				
Cytopreparative and cyto-diagnostic methods	Polycarbonate, mixed-esters of cellulose	2.0–8.0	25, 47	Use with Swin-Lok holder or vacuum filtration
		3.0–5.0	19×42	
<i>EPA testing</i>				
EPA toxicity characteristic leaching procedure (TCLP)	Glass fibre	0.7	90, 142	EPA Ref. 40CFR Part 268 Fed. Reg. 53:18795 May 24, 1988
<i>Fuel testing</i>				
	Mixed-esters of cellulose	0.45, 0.8	47	ASTM D2276
	Fuel monitor	0.8	37	
<i>General filtration</i>				
General clarification or prefiltration	Mixed-esters of cellulose	0.8–5.0	13–293	
	Glass fibre	D49, D59, D79	13–293	
Beverage stabilization	Mixed-esters of cellulose	0.45–1.2	47–293	
Particulate removal	Polycarbonate	0.1–5.0	13–293	
	Mixed esters of cellulose	0.1–5.0	13–293	
	Glass fibre (D49, D59, D79, 0.7 nominal)		10–293	

Table 8.21 (continued)

Application	Recommended filter media			References/comments
	Description	Pore size (μm)	Diameter (mm)	
Fine aqueous clarification	Polycarbonate	0.6–1.0	13–293	
	Mixed-esters of cellulose	0.65–1.2	13–293	
Bacterial removal	Mixed-esters of cellulose	0.22–0.45	13–293	
Adsorbable organic halogens (AOX)	Polycarbonate	AOX [®]	25, 47	
Alkaline elution, DNA	Polycarbonate	0.8, 2.0	25, 47	PORETRAITS [®] (NUCLEOPORE [®]) Winter 1988
Forensic analysis	Polycarbonate	0.4	13	Sample collection for S.E.M.
Liposome extrusion	Polycarbonate	0.1–0.4	25–76	Use with high-pressure holder
<i>HPLC solvent purification</i>				
Samples, aqueous	Mixed-esters of cellulose	0.45	13, 25	
Samples, organic Solvents	PTFE	0.45	4–25	
	PTFE	0.45	47	
<i>Parasitology</i>				
Microfilariae (<i>Dirofilaria immitis</i>)	Polycarbonate	5.0	2.5	Use Swin-Lok holder or stainless steel syringe holder
<i>Schistosoma haematobium</i>	Polycarbonate	12.0	13	
<i>Pharmaceuticals (human or veterinary)</i>				
Small volume parenterals	Syrfil [®] -MF	0.22	25	
Prefiltration	Glass fibre	D49–D79	10–293	Parenteral processing must conform with FDA GMPs; 21 CFR 210 and 211
Sterilization	Mixed-esters of cellulose	0.22	13–293	
<i>Protein or virus assay and purification</i>				
Fractionation or collection	Polycarbonate	0.015–0.1	25–293	For protein or virus filtration, use Stirred Cell Series – S25, S43, S76 Swin-Lock [®] holders, or stainless steel holders
Purification	Polycarbonate	0.015–0.4	25–293	
Colony hybridization	Mixed-esters of cellulose	0.45	25, 85	
Low binding	Polycarbonate	0.4	25	
<i>Serum filtration</i>				
Prefiltration	Glass fibre	D49–D79	10–293	
	Mixed-esters of cellulose	0.3–1.2	13–293	

Table 8.21 (continued)

Application	Recommended filter media			References/comments
	Description	Pore size (µm)	Diameter (mm)	
Bacterial removal	Mixed-esters of cellulose	0.1–0.22, 0.45	13–293	
Mycoplasma removal	Mixed-esters of cellulose	0.1	13–293	
<i>Sterilizing filtration</i>				
Air venting	Syrfil [®] -FN (PTFE)	0.2	25, 50	
Fluids-aqueous	Mixed-esters of cellulose	0.22, 0.45	90–293	
Air or gas	PTFE	0.2	25–293	
<i>Tissue culture media filtration</i>				
Prefiltration	Glass fibre	D49	47–293	
	Mixed-esters of cellulose	0.1	4–293	
Bacterial removal	Mixed-esters of cellulose	0.22	90–293	
Mycoplasma removal	Mixed-esters of cellulose	0.1	90–293	
<i>Water microbiology</i>				
<i>Escherichia coli</i>	Mixed-esters of cellulose	0.45	47	<i>Standard Methods/Water and Wastewater</i> , 17th Ed., 9260F
Fecal coliform	Mixed-esters of cellulose	0.7	47	<i>Standard Methods/Water and Wastewater</i> , 17th Ed., 9222D
Fecal streptococcus	Mixed-esters of cellulose	0.45	47	<i>Standard Methods/Water and Wastewater</i> , 17th Ed., 9230C
Fine particles	Mixed-esters of cellulose	0.45	47	
<i>Giardia lamblia</i>	Polycarbonate	5.0	293	Cyst Concentration and Analysis, EPA 600/S2-85/027 Sem. 1985
Leptospire	Mixed-esters of cellulose	0.45	13, 25	<i>Standard Methods/Water and Wastewater</i> , 17th Ed., 9260I
Phytoplankton	Mixed-esters of cellulose	1.2–5.0	47	<i>Standard Methods/Water and Wastewater</i> , 17th Ed., 10200C
Heterotrophic plate count (HPC) – formerly standard	Mixed-esters of cellulose	0.45	47	<i>Standard Methods/Water and Wastewater</i> , 17th Ed.,
Salmonella	Mixed-esters of cellulose	0.45	142	<i>Standard Methods/Water and Wastewater</i> , 17th Ed., 9260B
		0.45	47	

Table 8.21 (continued)

Application	Recommended filter media			References/comments
	Description	Pore size (μm)	Diameter (mm)	
Suspended particulates	Mixed-esters of cellulose	1.2–5.0	47	
	Polycarbonate	1.0–5.0	47	
	Glass fibre	0.7 nom	47	
Direct total microbial count	Polycarbonate	0.2	25	<i>Standard Methods/Water and Wastewater</i> , 17th Ed., 9216B
	Mixed-esters of cellulose	5.0	25	
Total coliform count	Mixed-esters of cellulose	0.45	47	<i>Standard Methods/Water and Wastewater</i> , 17th Ed., 9222B
<i>Vibrio cholerae</i>	Mixed-esters of cellulose	0.45	142	<i>Standard Methods/Water and Wastewater</i> , 17th Ed., 9260H
Virus concentration	Mixed-esters of cellulose	0.45	47, 90	<i>Standard Methods/Water and Wastewater</i> , 17th Ed., 9510B
	Glass fibre, D49		142	

and aluminium, and other ceramics. Membranes are produced as flat sheets, also used as spiral wound modules, and in tubular or hollow fibre forms.

The flux of the liquid through ultrafiltration membranes is much smaller than through microfiltration membranes, in the general range of 0.1–10 m³/day, the actual figure depending upon many structural parameters. For pure water (or other liquids) there is a linear correspondence between flux and transmembrane pressure. With solutions there is a tendency for the flux to reach an asymptotic value with increasing pressure. This is a result of several factors, including concentration polarization, gelation, fouling and osmotic effects.

The selection of a membrane for ultrafiltration will require determining the molar mass of the species to be separated and selecting a membrane with a limiting rejection ($R \approx 1.0$) under anticipated conditions of operation. Small-scale application tests will generally need to be performed. Ultrafiltration membranes are rated in terms of their nominal molecular weight cut-off (NMWC). There are no industry-wide standards for this rating, hence manufacturers use different criteria for assigning ultrafiltration pore sizes. For example, for the concentration of protein, the protein should be larger than the NMWC of the membrane by a factor of 2–5. The greater the difference (i.e. the tighter the membrane pore size), the higher the protein yield. The protein shape, in addition to its molecular weight, plays a role in determining its retention by the membrane. The more globular the protein, the greater its retention, while linear

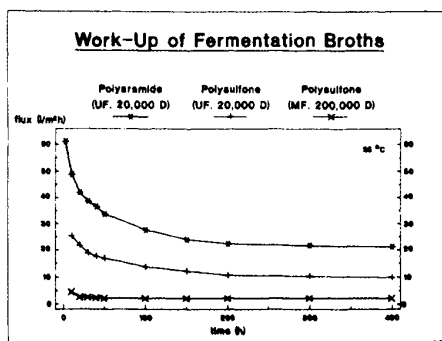


Figure 8.27. Variation of UF flux with conversion of a fermentation broth.

proteins may require a tighter membrane for high recoveries. Moreover, protein shape may be affected by solution pH or salinity.

Figure 8.27 shows the typical effect of time on the concentration of a fermentation broth with two types of ultrafiltration membrane, respectively hydrophilic polysulphone and polyaramid. Typically, the initial loss of flux is relatively rapid, whilst for longer times the decline in flux is less severe. The difference in the membrane flux behaviour is due to the greater tolerance of the very hydrophilic polyaramid membrane to fouling.

Although the separation mechanism of ultrafiltration is broadly considered to be one of sieving, in practice the effect of concentration polarization limits the flux, due to a build-up of solute in the concentration boundary layer on the feed side of the membrane. At sufficiently high pressures, gelation of the macromolecules can occur, resulting in the formation of a thin gel layer on the surface; this can act as a secondary membrane. Increasing the feed stream circulation rate will generally reduce the thickness of the gel layer and increase the flux. Operation within the turbulent flow regime may significantly enhance permeation by reducing the thickness of both the gel and fouling layers, by transferring solids from the membrane surface back into the bulk stream. As with microfiltration, factors of chemical compatibility of materials with the solution will need to be addressed.

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Exhibit 9



Handbook of Non-Woven Filter Media

Irvin M. Hutten



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BY AMANDA FISHER | AUG 30, 2019



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WHY BRANDS SHOULD VERIFY THEIR MARKETING CLAIMS

This article originally appeared in the September 2019 issue of Water Quality Products magazine as "Rise Up"



Today, water filter brands can either rise to the top or sink to the bottom of consumer consideration based on marketing claims. A strong brand value (<https://www.wqpmag.com/computer-software/digital-drama>) proposition coupled with a differentiating marketing claim can help catapult products off the shelf. A weak, invalid or unsubstantiated claim can cause a brand to suffer greatly, and negatively impact sales or brand reputation. So, what are the areas to be considered when working to develop marketing claims?

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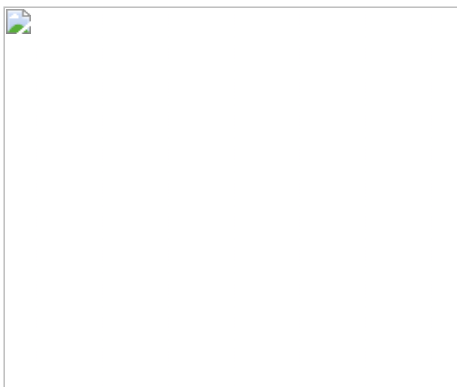
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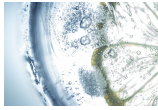
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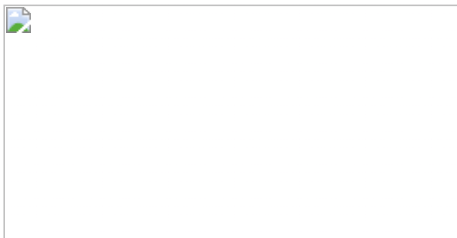
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JX-0023.0001

CLAIMS

What is claimed is:

1. A gravity-fed water filter, comprising:
filter media including at least activated carbon and a lead scavenger;
wherein the filter achieves a Filter Rate and Performance (FRAP) factor of about 350 or less
according to the following formula:

$$FRAP = \frac{[V * f * c_e]}{[L * 2]}$$

where:

V = volume of the filter media (cm^3),

f = average filtration unit time over lifetime L (min/liter),

c_e = effluent lead concentration at end of lifetime L when source water having a pH of 8.5
contains 90-120 ppb ($\mu\text{g/liter}$) soluble lead and 30-60 ppb ($\mu\text{g/liter}$) colloidal lead
greater than 0.1 μm in diameter, and

L = filter usage lifetime claimed by a manufacturer or seller of the filter (gallons).

2. The water filter as recited in claim 1, wherein the filter achieves a FRAP factor of less than about 200.
3. The water filter as recited in claim 1, wherein the volume of the filter media (V) is less than about 300 cm^3 .
4. The water filter as recited in claim 3, wherein the volume of the filter media (V) is less than about 150 cm^3 .
5. The water filter as recited in claim 1, wherein the average filtration unit time (f) is less than about 12 minutes per liter.

Brita LP Company

53

482.120B

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6. The water filter as recited in claim 5, wherein the average filtration unit time (f) is less than about 6 minutes per liter.
7. The water filter as recited in claim 1, wherein the filter media is present in the form of a block.
8. The water filter as recited in claim 7, further comprising a binder material interspersed with particles of the activated carbon.
9. The water filter as recited in claim 8, wherein the binder material has a melt index that is less than 1.8 g/10 min as determined by ASTM D 1238 at 190°C and 15 kg load.
10. The water filter as recited in claim 8, wherein the binder material has a melt index that is about 1.0 g/10 min as determined by ASTM D 1238 at 190°C and 15 kg load.
11. The water filter as recited in claim 7, wherein the filter fits within a container having a volume of less than about 20 in³.
12. The water filter as recited in claim 7, wherein the filter fits within a container having a volume of less than about 10 in³.
13. The water filter as recited in claim 7, wherein the block comprises multiple sub-blocks, each of the sub-blocks comprising filter media walls surrounding and defining a cavity for receiving fluid.
14. The water filter as recited in claim 7, wherein the block comprises multiple sub-blocks, each of the sub-blocks comprising filter media walls surrounding and defining on four sides a cavity for receiving fluid.

15. The water filter as recited in claim 13, wherein the block has an exterior space, gap, or recess between at least a portion of the multiple sub-blocks.
16. The water filter as recited in claim 7, wherein the block has an open top for receiving unfiltered water into a cavity thereof.
17. The water filter as recited in claim 7, wherein a median sidewall thickness of the block is less than about 0.6 inch.
18. The water filter as recited in claim 7, wherein a median sidewall thickness of the block is less than about 0.4 inch.
19. The water filter as recited in claim 7, wherein a structure of the block is characterized by having been compressed no more than 10% by volume during fabrication of the filter.
20. The water filter as recited in claim 1, wherein the filter media comprises primarily particles that are not bound together.
21. The water filter as recited in claim 1, wherein the filter media is present in the form of granular carbon.
22. The water filter as recited in claim 1, wherein the lead scavenger is a zirconia oxide or hydroxide
23. A gravity-flow system for filtering water, comprising:
 - a container having a source water reservoir than can hold source water and a filtered water reservoir that can hold filtered water;

a cartridge in communication with both the source water reservoir and the filtered water reservoir, the cartridge providing a path through which water can flow from the source water reservoir to the filtered water reservoir; and
a filter as recited in claim 1 disposed within the cartridge.

24. The gravity-flow system as recited in claim 23, wherein the cartridge has an aperture through a sidewall thereof for allowing at least egress of air into the filtered water reservoir.

25. A gravity-fed carbon block water filter, comprising:
a solid profile filter block comprising multiple sub-blocks, each of the sub-blocks comprising filter media walls surrounding and defining a cavity for receiving fluid, and each of the sub-blocks being connected to at least one other of the sub-blocks by filter media of which the filter block is made;
wherein a lead concentration in a final liter of effluent water filtered by the filter is less than about 10 µg/liter after about 151 liters (40 gallons) of source water filtration, the source water having a pH of 8.5 and containing 135-165 parts per billion total lead with 30-60 parts per billion thereof being colloidal lead greater than 0.1 µm in diameter.

NSF/ANSI 53 – 2007

Drinking water treatment units — Health effects

**NSF International Standard/
American National Standard**

NSF/ANSI 53 – 2007



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This Standard is subject to revision.
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for Drinking Water Treatment Units —
**Drinking water treatment units –
Health effects**

Standard Developer
NSF International

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NSF International Board of Directors

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February 5, 2007
American National Standards Institute

3 Definitions

The following terms are used in this document:

3.1 absorption: The physical process occurring when one substance actually penetrates the structure of another substance, termed the absorbent.

3.2 accessible: Fabricated to be exposed for cleaning and inspection using simple tools (e. g., screwdriver, pliers, open-end wrench).

3.3 active agent: A substance or medium, added to or involved in the treatment process, that requires direct or sacrificial release of the agent or degraded product to reduce specific contaminants in the water.

3.4 additive: A substance added to water, directly or indirectly, during a drinking water treatment process.

3.5 adsorption: The physical process occurring when liquids, gases, or dissolved or suspended matter adhere to the surface of, or in the pores of, an adsorbent medium. Adsorption is a physical process that occurs without chemical reaction.

3.6 advisory concentration: The minimum concentration attainable for a given substance using good manufacturing practices and appropriate process controls. In some cases, the advisory concentration is equal to the limit of detection of the preferred analytical method for the substance.

3.7 aesthetic: Pertaining to factors such as taste, odor, color, and appearance that affect drinking water and, therefore, may deter acceptance of public and private drinking water.

3.8 air gap: An unobstructed vertical distance of 2 pipe diameters or 25 mm (1 in), whichever is greater, through the free atmosphere between the outlet of the waste pipe and the flood level rim of the receptacle into which it is discharging.

3.9 backwash: The upflow or counter-current flow of water through a filter medium, for the purpose of thoroughly expanding the medium to remove foreign particulate matter accumulated during the service cycle and flushing it to the drain.

3.10 bed volume: Total volume of the media including the void spaces between the medium particles.

3.11 bypass: (verb) To flow around a water treatment system or its media. (noun) A valve system that allows water to flow around the water treatment system while the system is being regenerated or serviced.

3.12 capacity: The rated service cycle, expressed as a function of time or volume, of water treated by a system, between servicing of the media (cleaning, regeneration, or replacement), as specified by the manufacturer.

3.13 chemical reduction: The reduction in the quantity of one or more specified organic or inorganic contaminants in drinking water.

3.14 clean system: A unit that has not been subjected to an influent challenge containing a specified contaminant(s).

3.15 commercial modular system: A system consisting of multiple modular elements attached to a manifold, produced specifically for food service applications, installed by an authorized plumber or authorized agent of the manufacturer, and not intended for use in residential applications.

- 3.16 component:** A separate or distinct part of a drinking water treatment system.
- 3.17 contaminant:** Any undesirable physical, chemical, or microbiological substance in drinking water that may have an adverse health or aesthetic effect, or both.
- 3.18 cyst:** The resistant stage in the life cycle of waterborne protozoa that may be found in surface drinking water supplies and includes oocysts of *Cryptosporidium* and *Toxoplasma* and cysts of *Giardia* and *Entamoeba*.
- 3.19 degradation product:** A product of an active agent or additive that has been altered by biological, chemical, or physical interaction.
- 3.20 disposable pressure vessel:** A pressure vessel that is to be replaced at the end of each rated service cycle and has an estimated service life of one year or less.
- 3.21 drinking water:** Water that is intended for human consumption.
- 3.22 exposure water:** Water having definitive characteristics, prior to contact with a system or component(s) in extraction procedures.
- 3.23 extractant water:** Water that has been in contact with a system or component(s) for a specified duration.
- 3.24 fiber:** A particle with a length three or more times its width or diameter (excludes organisms).
- 3.25 filter:** (verb) To pass water containing particles through a semi-permeable material (e. g., charcoal, fabric, filament) to separate the particles from the water. (noun) A system for carrying out the process of filtration; it consists of the filter medium and suitable hardware for constraining and supporting the filter medium in the path of the water.
- 3.26 filter area:** The effective area at which water first contacts the filter medium.
- 3.27 filter medium:** The semi-permeable material used to separate particulate matter from water.
- 3.28 filtration:** The process by which particles are separated from water by passing water through a permeable material.
- 3.29 flow rate:** The volume of water that passes through a system in a specified amount of time.
- 3.30 influent challenge:** The mixture of water and contaminants entering a system.
- 3.31 initial dynamic pressure:** The pressure as measured at a pressure gauge immediately preceding connection to the system being tested (see figure 1) when the system is filled with water and flowing.
- 3.32 maximum contaminant concentration (MCC):** The maximum permissible concentration of a contaminant in drinking water as established by a recognized regulatory agency, such as the USEPA or Health Canada.
- 3.33 maximum contaminant level (MCL):** The maximum permissible concentration of a contaminant or substance in drinking water, as established in the *National Primary Drinking Water Regulations*.
- 3.34 maximum drinking water level (MDWL):** The maximum concentration of a contaminant or substance in drinking water that a system is allowed to contribute to the effluent, as established in this Standard.

- 3.35 mechanical filtration system:** A system that mechanically separates particulate matter from water.
- 3.36 medium (media):** The selected material in a system that forms a water-permeable barrier to the passage of certain contaminants.
- 3.37 medium migration:** The entrainment of a fraction of the medium into the effluent.
- 3.38 microbiologically unsafe water:** Water that (1) is known to contain disease-causing bacteria, viruses, protozoa, or other disease-causing microbiological agents; (2) shows a positive test for an indicator organism; or (3) is determined unsafe by an appropriate health or regulatory agency.
- 3.39 modular element:** A replaceable filtration or treatment element designed and sold as a component for use in commercial modular systems.
- 3.40 open discharge system:** A system not subject to line pressure during the off mode.
- 3.41 point-of-entry system:** A system used to treat all or part of the water at the inlet to a residential facility (where the inlet connection is 25 mm [1 in] or less), or at a bottled water production facility employing mechanical filtration devices containing non-stacked filters (where the inlet connection may be greater than 25 mm [1 in]).
- 3.42 point-of-use system:** A plumbed-in or faucet-mounted system used to treat the water at a single tap or multiple taps but not used to treat the water for the majority of the facility. A batch system is considered a point-of-use system.
- 3.43 pressure drop:** The difference between the inlet and outlet pressures of a system at the rated service flow rate.
- 3.44 pressure vessel:** A component of a system intended to hold water under pressure higher than atmospheric pressure.
- 3.45 product water:** Water that has been treated by a system.
- 3.46 rated service cycle:** The capacity of a system expressed as a function of time, or volume of water to be treated, between cleaning replacement or regeneration of the media, as specified by the manufacturer.
- 3.47 rated service flow:** The flow rate at which the system will deliver treated water of acceptable quality, as claimed by the manufacturer. Flow rate is expressed as liters (gallons) per minute, or liters (gallons) per day.
- 3.48 raw water:** Untreated water or any influent water before it enters a specific water treatment component or system.
- 3.49 readily accessible:** Fabricated to be exposed for cleaning and inspection without using tools.
- 3.50 readily (or easily) removable:** Capable of being separated from the system without using tools.
- 3.51 refrigerator filter:** A filter system incorporated into a residential refrigerator appliance.
- 3.52 regeneration:** The maintenance process that restores a medium to perform its water treatment function(s).
- 3.53 replacement component:** A replaceable, preformed, or prepackaged component containing a medium (media).

3.54 secondary maximum contaminant level (SMCL): The maximum permissible level of a contaminant or substance in drinking water, as established in the *National Secondary Drinking Water Regulations*.

3.55 system: A complete water treatment device, including all components needed to connect it to a potable water supply.

3.56 total dissolved solids (TDS): The remaining solids from a filtrate evaporated to dryness and dried to a constant weight at 180 °C (356 °F) after passing through a glass fiber filter.

3.57 turbidity: A condition caused by the presence of suspended matter, or colloidal matter, or both, which results in the scattering and absorption of light rays.

3.58 unit void volume: Total water holding volume with the filter medium, components, or both in place.

3.59 unit volume: Total water holding volume without the filter medium, components, or both, in place.

3.60 watertight: Having such precision of construction and fit as to be impermeable to water.

3.61 weepage: The formation of bubbles or droplets of water on the outside of a fiber glass tank during the initial phase of a pressure test, due to the expression of water that was trapped between the tank liner and the fiberglass wrap during the tank manufacturer's testing.

3.62 working pressure: Feedwater or inlet water pressure to a system.

3.62.1 maximum working pressure: The maximum operating pressure recommended by the manufacturer.

7.4.3 Lead reduction testing**7.4.3.1 Lead reduction claims**

To qualify for a lead reduction claim, all systems shall meet the requirements of 7.4.3 for the lead pH 6.5 and lead pH 8.5 reduction testing. If, during the lead pH 8.5 reduction testing, the flow rate through the system is reduced by 75% of the initial clean flow rate after reaching 100% of the rated capacity and the lead effluent concentrations are less than or equal to the maximum effluent concentration shown in table 14, the system shall qualify for the lead reduction claim.

Table 14 – Lead reduction requirements

Substance ⁵	Influent challenge ¹	Overall average tolerance	Single point tolerance	Maximum effluent conc. mg/L	USEPA method	Compound
Lead [Pb] _i	0.15 mg/L	± 10%	± 20%	0.010	200.8, 200.9 ⁴	Pb(NO ₃) ₂
Lead %[Pb] _{tp} ²	30 %	± 10% ³	± 20% ³	n/a	200.8, 200.9 ⁴	
Lead %[Pb] _i ²	≥ 20 %	n/a	n/a	n/a	200.8, 200.9 ⁴	

¹ Reason for influent challenge levels: challenge concentrations should be selected to simulate what a system will be challenged with in the field and/or to provide an accurate and reproducible indicator of performance. The following sequence of criteria may be used to select challenge concentrations:

^{1a} The upper percentile concentration of available occurrence data (the concentration for which there is high probability [P<0.05] that 95 percent of the population will be exposed to waters of lower concentration). Occurrence data shall come from national monitoring programs administered by the USEPA or the USGS. Other occurrence data shall be accepted by the Joint Committee on Drinking Water Treatment Units.

^{1b} The concentration obtained by multiplying the USEPA's published maximum contaminant level by three. This concentration will not be adequate when USEPA MCL is very low.

² Requirements for the lead pH 8.5 test only. A maximum of one sample point (influent and effluents if present) may be discarded if these requirements are not met; the discarded sample point cannot be the final capacity sample point of the test (120 or 200 percent).

³ Percentage variance allowed; for example, total particulate lead (Lead %[Pb]_{tp}) is allowed an overall average tolerance of 20 – 40% (30 ± 10%).

⁴ USEPA Method 200.7 may be used for analysis of influent sample concentrations only.

⁵ Pb_i is total lead, Pb_{tp} is total particulate lead, and Pb_r is the portion of total particulate lead that is between 0.1 and 1.2 microns in size (fine).

7.4.3.2 Apparatus

Refer to 7.1.2, figure 2, for an example of the test apparatus.

7.4.3.3 Analytical methods

7.4.3.3.1 All analyses shall be conducted in accordance with the applicable methods referenced in 2.

7.4.3.3.2 Determination of particulate lead in pH 8.5 testing

Influent lead samples shall be collected from a non-glass sampling vessel. A portion representing the total lead $[Pb_t]$ sample shall be transferred immediately to a non-glass sample bottle that contains adequate nitric acid to lower the pH of the sample to below 2.0.

A second portion of the same influent collected from the non-glass sampling vessel shall be immediately passed through a 0.1 micron absolute filter and collected into a non-glass sample bottle that contains adequate nitric acid to lower the pH of the sample below 2.0. This sample is the 0.1 micron filtrate lead sample $[fPb_{0.1}]$.

A third portion of the same influent collected from the non-glass sampling vessel shall be immediately passed through a 1.2 micron absolute filter and collected into a non-glass bottle that contains adequate nitric acid to lower the pH of the sample below 2.0. This sample is the 1.2 micron filtrate lead sample $[fPb_{1.2}]$.

The total particulate lead $[Pb_{tp}]$ shall be calculated as follows:

$$[Pb_{tp}] = [Pb_t] - [fPb_{0.1}]$$

The percent of total particulate lead $\%[Pb_{tp}]$ shall be calculated as follows:

$$\%[Pb_{tp}] = \{[Pb_t] - [fPb_{0.1}]\} \div [Pb_t] \times 100$$

Fine particulate lead $[Pb_f]$ shall be the portion of particulate lead between 0.1 and 1.2 micron, and shall be calculated as follows:

$$[Pb_f] = [fPb_{1.2}] - [fPb_{0.1}]$$

Percent of fine particulate lead $\%[Pb_f]$ shall be calculated as follows:

$$\%[Pb_f] = \{[Pb_f] \div [Pb_{tp}]\} \times 100$$

The filter apparatus for particulate lead sample preparation shall consist of a polypropylene syringe attached to a 0.1 or 1.2 micron absolute disposable syringe filter (Pall Acrodisc® supor® membrane, 32 mm¹³ or Millipore Millex-VV® PVDF membrane¹⁴) or a filter system that has been validated by the analysis of a minimum of seven sample pairs of the lead test water in parallel with one of the recommended filter membranes. Filtration should be conducted under moderate pressure with a recommended maximum delivery rate of 1 mL/sec. The filtered and unfiltered sample pairs shall be evaluated using a statistical paired two samples for means t-test at 95% confidence, n=7 (or greater), and hypothesized mean difference of zero (no statistical difference).

7.4.3.4 Servicing of components

If clogging occurs, systems with separate mechanical filtration components shall have the mechanical filtration components replaced or serviced in accordance with the manufacturer's instructions to maintain the test flow rate.

¹³ Pall Corporation, 2200 Northern Boulevard, East Hills, NY 11548

¹⁴ Millipore, 290 Concord Road, Billerica, MA 01821

7.4.3.5 Metals reduction waters for lead**7.4.3.5.1 Test water for lead pH 6.5 testing**

A public water supply shall be used and the following specific characteristics shall be maintained throughout the test for metals reduction claims:

alkalinity (as CaCO ₃)	10 – 30 mg/L
hardness (as CaCO ₃)	10 – 30 mg/L
pH	6.5 ± 0.25
polyphosphate (as P)	< 0.5 mg/L
TDS	< 100 mg/L
temperature	20 ± 2.5 °C (68 ± 5 °F)
turbidity	< 1 NTU

NOTE – Where precipitation of the metals occurs, deionized water shall be used instead of water from a public water supply. Appropriate calcium salts, or magnesium salts, or both, shall be added to provide the desired TDS (refer to table of standard Ksp values). The pH adjustment required shall not cause precipitation of the metals.

7.4.3.5.2 Test water for lead pH 8.5 testing

The lead pH 8.5 test water shall be prepared following the prescribed procedure in order to control the formation of a specific amount of particulate lead. The formation of particulate lead is sensitive to the cleanliness of the equipment, the design of the equipment, and exact methods used. The amount of total particulate lead [Pb_t] and fine particulate lead [Pb_f] in the test water is determined as described in 7.4.3.3.2.

7.4.3.5.2.1 Demonstration of laboratory capability

The test equipment used and the procedures employed for conducting the test shall demonstrate the capability of meeting the requirements for the lead pH 8.5 test. Each type of test equipment or apparatus (refer to 7.1.2, figure 2) used for lead pH 8.5 testing shall be validated under this section.

Each type of test equipment used for lead pH 8.5 testing shall be validated against this procedure prior to testing. The test water shall be prepared as required under 7.4.3.5.2.3 three times for each type of test equipment. The test equipment shall deliver the test water to the test unit connection points and maintain the total and particulate lead percentages over a minimum of 24 h for each test water preparation as follows:

Total Lead Concentration (ug/L) [Pb _t]	All influent samples shall be within 10% of the mean over 24 h.
Total Percent Particulate Lead %[Pb _{tp}]	Average 20 – 40%, all sample points within 10 – 50%.
Percent Fine Particulate Lead %[Pb _f]	Minimum of 20% for all sample points.

Samples shall be collected 20 min, 4 h, 8 h, and 24 h after the completion of test water preparation. Samples shall be collected from the test unit connection (or dispensing) points on the test equipment.

7.4.3.5.2.2 Test equipment cleaning and conditioning

The test equipment shall have all surfaces in contact with the test water cleaned prior to testing to remove excess particulate and biological material. Test equipment that is used exclusively for lead pH 8.5 reduction can conduct several tests sequentially if the particulate levels specified in 7.4.3.5.2.1 are maintained.

NOTE – Experience in the laboratory has suggested that a dedicated tank should not be used for longer than 21 days without cleaning. This is highly dependent on the construction of the tank system as well as the cleaning method.

7.4.3.5.2.2.1 Test equipment cleaning

The test equipment shall be cleaned using an acid wash to remove excess particulate from the test equipment. This shall be accomplished by filling the equipment with a 0.003 N HCl solution and recirculating through the tank and plumbing for 2 h. A RO/DI rinse shall be completed after the acid wash. Other acidic solutions may be used if they are shown to clean the test rig properly without adversely affecting the formation of particulate lead.

7.4.3.5.2.2.2 Test equipment conditioning

The test equipment shall be conditioned after cleaning by adding 150 ppb lead from the acidified stock to RO/DI water for a minimum of 8 h (pH below 7.5). The lead solution shall be circulated through the tank and plumbing to condition all of the wetted surfaces. Modification of the conditioning procedure may be made if it is demonstrated that the modifications improve the stability or formation of total and particulate lead.

7.4.3.5.2.3 Lead pH 8.5 reduction test water

The lead pH 8.5 reduction test water shall be prepared as follows:

- 1) A water supply shall be treated by reverse osmosis and then shall be treated with deionization (RO/DI water) and shall have a conductivity of less than 2 μ S/cm. A test equipment tank shall be filled with the RO/DI water.
- 2) Use reagent grade chemicals for all additions to adjust the RO/DI water to meet the following specific characteristics:

Parameter	Target Value	Overall Average Tolerance	Single Point Tolerance
hardness (as CaCO ₃)	100 mg/L	± 10%	± 20%
alkalinity (as CaCO ₃)	100 mg/L	± 10%	± 20%
total chlorine	0.50 mg/L	± 0.25 mg/L	± 0.25 mg/L
pH	8.5	8.30 – 8.60	8.25 – 8.75
temperature	20.0 °C	± 2.5 °C	± 2.5 °C

7.4.3.5.2.3.1 Solution preparation

The solutions for generating the lead pH 8.5 test water shall be prepared as follows:

- Calcium Chloride Solution

Add Calcium Chloride (CaCl₂•2H₂O) to RO/DI H₂O to obtain a solution concentration of 38 g/L.

- Magnesium Sulfate Solution

Add Magnesium Sulfate (MgSO₄•7H₂O) to RO/DI H₂O to obtain a solution concentration of 32 g/L.

- Sodium Bicarbonate Solution

Add Sodium Bicarbonate (NaHCO₃) to RO/DI H₂O to obtain a solution concentration of 63 g/L.

– Sodium Hypochlorite Solution

Commercial grade bleach solution may be used with a concentration between 5 – 7% NaClO.

– Soluble Lead Stock Solution

4 mL 1:1 diluted concentrated Nitric Acid to 1 L RO/DI H₂O; then add 3.6 g Pb(NO₃). Store the solution in a plastic container for no more than 90 days.

– Insoluble Lead Stock Solution

Add 1.6 g Pb(NO₃) to 1 L RO/DI H₂O (RO/DI pH should be already below 6.5; if it is not, let the water sit with exposure to the atmosphere until its pH is below 6.5). Store the solution in a plastic container for no more than 30 days.

7.4.3.5.2.3.2 Method of test water preparation

1) Mix tank during all additions. Mix the solution adequately after the addition of all chemicals prior to pH adjustment to ensure a homogeneous solution.

2) Mix the tank again after each pH adjustment or lead addition to ensure homogeneity.

NOTE – Length and type of mixing may affect the amount of total particulate lead and the relative amounts of fine and coarse particulate lead. High-speed vortex mixing of the tank for extended periods of time should be avoided. Mixing should be minimized after the initial formation of lead particulate to improve the stability of the fine particulate.

3) Do not mix tank excessively during use; only mix enough to ensure a homogeneous challenge. It is recommended that mixing occur at a maximum of 5 min/h.

4) Do not use the tank of test water for longer than 24 h.

5) Add chemicals and make adjustments in order as listed in the table below. Use the exact chemical formula as indicated. Adjustments may be made in the amount added to meet the specific characteristics under 7.3.4.5.2.3. Sequence and method of additions must be adhered to for the proper formation of particulate lead. The procedure may be scaled up or down depending on the volume requirements of the test.

Action	Chemical Name	Formula	Per 380 liters (100 gallons)
Fill tank with RO/DI Water	RO/DI Water	H ₂ O	380 L
add magnesium solution	Magnesium Sulfate (32 g/L)	MgSO ₄ •7H ₂ O	1.0 L
add calcium solution	Calcium Chloride (38 g/L)	CaCl ₂ •2H ₂ O	1.0 L
Add bicarbonate solution	Sodium Bicarbonate (63 g/L)	NaHCO ₃	1.0 L
Add bleach solution	Sodium Hypochlorite (6% bleach)	NaClO	4 mL
Adjust pH of solution	Sodium Hydroxide or Hydrochloric Acid	NaOH or HCl	as needed
Verify temperature			
Verify total chlorine			
Add soluble lead stock solution	Lead Stock Solution – Soluble ¹	Pb(NO ₃) ₂	20 mL ¹
Add insoluble lead stock – see preparation method	Lead Stock Solution – Insoluble ²	Pb(NO ₃) ₂	20 mL ²

¹ Add directly to tank.² Insoluble Lead Preparation:

- 1) Use a plastic container that is sized no larger than 100 times (100x) the volume of stock solution required for the volume of test water being prepared (example: if 20 mL of insoluble lead stock is used, a container no larger than 2L shall be used).
- 2) Fill the container with prepared tank water (after temperature and chlorine are verified) to a volume that is equal to 50 times (50x) the volume of insoluble lead stock solution required for the volume of test water being prepared (example: if 20 mL of insoluble lead stock is used, 1,000 mL of prepared tank water is added).
- 3) Place the plastic container on a stir plate with a PTFE coated stir bar. Turn the stir plate speed up until the solution is mixing rapidly and a strong vortex to the bottom of the container is formed.
- 4) Measure out the required volume of insoluble lead stock solution in a non-glass measuring vessel and add the stock solution all at once to the mixing solution in the container.
- 5) Allow the solution to mix for 60 s and then immediately pour the solution into the entire tank volume.

7.4.3.6 Cycle time

The systems shall be operated on a 50%-on / 50%-off cycle basis with a 15- to 40-min cycle, 16 h per 24-h period, followed by an 8-h rest under pressure (a 10%-on / 90%-off cycle may be used if requested by the manufacturer).

7.4.3.7 Methods

7.4.3.7.1 Plumbed-in systems without reservoirs and all faucet-mounted systems

Two systems shall be conditioned in accordance with the manufacturer's instructions using the test water specified in 7.4.3.5. The systems shall be tested using the appropriate influent challenge water at the maximum flow rate attainable by setting an initial dynamic pressure of 410 ± 20 kPa (60 ± 3 psi). The pressure shall not be readjusted although the system may experience some change in dynamic pressure. The operating cycle specified in 7.4.3.6 shall be used.

7.4.3.7.1.1 Refrigerator filters without integral flow control

Chemical reduction testing for refrigerator filters without an integral automatic fixed flow-rate control shall be performed at a controlled flow rate that is equal to or greater than the rated service flow of the refrigerator filter system and refrigerator plumbing.

7.4.3.7.1.2 Refrigerator filters without integral flow control, with water dispenser and ice maker

If the refrigerator filter does not include an integral automatic fixed flow-rate control, and supplies water to both a water dispenser and an ice maker, then any chemical reduction testing shall be performed at a controlled flow rate equal to or greater than the tested flow rate of the icemaker or the tested flow rate of the water dispenser, whichever is greater.

7.4.3.7.2 Plumbed-in systems with reservoirs

The method specified in 7.4.3.7.1 shall be followed except that where the design of the system does not lend itself to the operating cycle specified in 7.4.3.6, the operating cycle shall be a repetitive complete filling and emptying of the reservoir. This cycle may be continued for 24 hours per day.

7.4.3.7.3 Nonplumbed pour-through-type batch treatment systems

Two systems shall be tested using the appropriate challenge and influent water after establishment of the manufacturer's recommended use pattern, with automatic cycling. If there is not a recommended use pattern, the systems shall be operated on the basis of four times the bed volume per batch. The cycle shall include a rest period of 15 to 60 s between batches, timed from the cessation of streamed flow.

7.4.3.8 Sampling

During performance of the lead pH 8.5 test, in addition to total lead $[Pb_t]$ for each influent sample, total percent particulate $\%[Pb_{tp}]$, percent fine particulate $\%[Pb_f]$, and percent coarse particulate $\%[Pb_c]$ shall be determined at each influent sample point, but not to exceed one set of samples per prepared tank of test water. The pH of the influent shall be analyzed prior to each influent sample point and verified to meet the requirements in 7.3.4.5.2.3. All reported influent lead samples shall meet the requirements in Table 13.

For systems with performance-indication devices, during the "on" portion of the cycle, influent and effluent samples shall be collected at the start of the test (after the passage of 10 unit volumes of influent challenge) and at 25%, 50%, 75%, 100%, and 120% of the estimated capacity. For systems without performance indication devices, the system shall be tested to 200% of the estimated capacity. Samples shall be collected at startup (after the passage of 10 unit volumes) and at 50%, 100%, 150%, 180%, and 200% of the estimated capacity. Samples for each system shall be at least one unit volume.

7.4.4 Mercury reduction testing**7.4.4.1 Mercury reduction claim**

Claims for mercury reduction may be made when tested in accordance with 7.4.4.1. To qualify for a mercury reduction claim, the system shall reduce the influent concentration(s) so that all effluent concentrations are less than or equal to the maximum effluent concentrations shown in table 14.

Table 15 – Mercury reduction requirements

Substance	Influent challenge ¹ mg/L	Maximum effluent concentration mg/L	USEPA method(s)	Compound
mercury	0.006 ± 10% ^{1b} (added as inorganic mercury)	0.002	200.8	Hg(NO ₃) ₂ · H ₂ O
¹ Reason for influent challenge levels: challenge concentrations should be selected to simulate what a system will be challenged with in the field and/or to provide an accurate and reproducible indicator of performance. The following sequence of criteria is used to select challenge concentrations: ^a The upper percentile concentration of available occurrence data (the concentration for which there is high probability [P < 0.05] that 95% of the population will be exposed to waters of lower concentration). Occurrence data shall come from national monitoring programs administered by the USEPA or the USGS. Other occurrence data shall be accepted by the Joint Committee on Drinking Water Treatment Units. ^b The concentration obtained by multiplying the USEPA's published maximum contaminant level by three. This concentration will not be adequate when USEPA MCL is very low.				

7.4.4.2 Apparatus

Refer to 7.1.2, figure 2, for an example of the test apparatus.

7.4.4.3 Analytical methods

All analyses shall be conducted in accordance with the applicable methods referenced in 2.

7.4.4.4 Servicing of components

If clogging occurs, systems with separate mechanical filtration components shall have the mechanical filtration components replaced or serviced in accordance with the manufacturer's instructions to maintain the test flow rate.

7.4.4.5 Mercury reduction test waters

A public water supply or RO/DI water (if premature clogging is of concern) shall be used and the following specific characteristics shall be maintained throughout the test for mercury reduction claims:

	low pH	high pH
alkalinity (as CaCO ₃)	10 – 30 mg/L	100 – 250 mg/L
hardness (as CaCO ₃)	10 – 30 mg/L	100 – 200 mg/L
PH	6.5 ± 0.25	8.5 ± 0.25
polyphosphate (as P)	< 0.5 mg/L	< 0.5 mg/L
TDS	< 100 mg/L	200 – 500 mg/L
temperature	20 ± 2.5 °C (68 ± 5 °F)	20 ± 2.5 °C (68 ± 5 °F)
turbidity	< 1 NTU	< 1 NTU

7.4.4.5.1 Mercury reduction pH 8.5 test waters

Appropriate calcium, or magnesium salts, or both, shall be added to provide the desired TDS (refer to table of standard Ksp values). The pH adjustment required shall not cause precipitation of the metals.

7.4.4.6 Cycle time

The systems shall be operated on a 50%-on / 50%-off cycle basis with a 15- to 40-min cycle, 16 h per 24-h period, followed by an 8-h rest under pressure (a 10%-on / 90%-off cycle may be used if requested by the manufacturer).

7.4.4.7 Methods**7.4.4.7.1 Plumbed-in systems without reservoirs and all faucet-mounted systems**

Two systems shall be conditioned in accordance with the manufacturer's instructions using the appropriate general test water specified in 7.4.4.5. The systems shall be tested using the appropriate influent challenge water at the maximum flow rate attainable by setting an initial dynamic pressure of 410 ± 20 kPa (60 ± 3 psi). The pressure shall not be readjusted although the system may experience some change in dynamic pressure. The operating cycle specified in 7.4.4.6 shall be used.

7.4.4.7.2 Plumbed-in systems with reservoirs

The method specified in 7.4.4.7.1 shall be followed except that where the design of the system does not lend itself to the operating cycle specified in 7.4.4.6, the operating cycle shall be a repetitive complete filling and emptying of the reservoir. This cycle may be continued for 24 hours per day.

7.4.4.7.3 Nonplumbed pour-through-type batch treatment systems

Two systems shall be tested using the appropriate challenge and influent water after establishment of the manufacturer's recommended use pattern, with automatic cycling. If there is not a recommended use pattern, the systems shall be operated on the basis of four times the bed volume per batch. The cycle shall include a rest period of 15 to 60 s between batches, timed from the cessation of streamed flow.

7.4.4.8 Sampling

For systems with performance-indication devices, during the "on" portion of the cycle, influent and effluent samples shall be collected at the start of the test (after the passage of 10 unit volumes of influent challenge) and at 25%, 50%, 75%, 100%, and 120% of the estimated capacity. For systems without performance indication devices, the system shall be tested to 200% of the estimated capacity. Samples shall be collected at startup (after the passage of 10 unit volumes) and at 50%, 100%, 150%, 180%, and 200% of the estimated capacity. Samples for each system shall be at least one unit volume.

8 Instruction and information**8.1 Installation, operation, and maintenance instructions**

8.1.1 Information setting forth complete, detailed instructions for installation, operation, and maintenance shall be provided with each system. Specific instructions shall include:

- complete name, address, and telephone number of manufacturer;
- model number and trade designation;
- flushing and conditioning procedures;
- rated service flow in L/min or L/day (gpm or gpd);
- maximum working pressure in kPa (psig);

- maximum operating temperature in degrees C (degrees F);
- detailed installation instructions including an explanation or schematic diagram of proper connections to the plumbing system;
- operation and maintenance requirements (including user responsibility, parts, and service);
- sources of supply for replaceable components;
- statement noting the need for the system and installation to comply with state and local laws and regulations;
- statement noting that the system is to be supplied only with cold water;
- statement noting that the system conforms to NSF/ANSI 53 for the specific performance claims verified and substantiated by test data;
- for systems used in bottled water plants, a statement noting the redundant filtration element sealing mechanism, such as 222 and 226 double o-ring seals; and
- statement for arsenic reduction systems:

“This system has been tested for the treatment of water containing pentavalent (also known as As(V), As(+5), or arsenate) and trivalent arsenic (also known as As(III), As(+3), or arsenite) at concentrations of [0.050 mg/L or 0.30 mg/L] or less. This system reduces both forms of arsenic below EPA MCL. Please see the Arsenic Facts section of the Performance Data Sheet for further information.”

8.1.2 Where applicable and appropriate, the following information shall also be included:

- model number(s) of replacement components;
- rated capacity / rated service life in liters (gallons);

NOTE – Each unique model designation shall not claim a capacity or service life greater than the least reduction capacity or service life that has been verified through testing to NSF/ANSI 53.
- minimum working pressure in kPa (psig);
- minimum operating temperature in degrees C (degrees F);
- electrical requirements;
- statement for activated carbon systems: “Do not use with water that is microbiologically unsafe or of unknown quality without adequate disinfection before or after the system.” Additional statement for activated carbon systems claiming cyst reduction: “Systems certified for cyst reduction may be used on disinfected waters that may contain filterable cysts.”;
- explicit instructions explaining how the performance indicator functions;
- diagram showing proper air gap installation to waste connections;

- for systems claiming radon reduction, a statement that the system shall not be used on water sources with a radon activity greater than 4000 pCi/L and the manufacturer's recommended replacement schedule for the carbon filter (to a maximum of one year); and

- for systems claiming radon reduction, a statement that the system treats radon from drinking water only and does not reduce radon from indoor air.

8.1.3 Where appropriate and applicable, and where product packaging contains information for the prospective purchaser, the following information shall be included on the product packaging in a location visible to the purchaser:

- statement for pentavalent arsenic reduction systems: "This system has been tested for the treatment of water containing pentavalent arsenic (also known as As(V), As(+5), or arsenate) at concentrations of [0.050 mg/L or 0.30 mg/L] or less. This system reduces pentavalent arsenic, but may not reduce other forms of arsenic. This system is to be used on water supplies containing a detectable free chlorine residual or on water supplies that have been demonstrated to contain only pentavalent arsenic. Treatment with chloramine (combined chlorine) is not sufficient to ensure complete conversion of trivalent arsenic to pentavalent arsenic. Please see the Arsenic Facts section of the Performance Data Sheet for further information."

8.2 Data plate

8.2.1 A permanent plate or label shall be affixed in a readily accessible location on each system, and shall contain, at a minimum, the following information:

- model number;
- name and address of manufacturer;
- functional description of system (e. g., chemical reduction or mechanical reduction, or both);
- maximum operating temperature in degrees C (degrees F);
- maximum working pressure in kPa (psig); and
- statement noting that the system conforms to NSF/ANSI 53 for the specific performance claims verified and substantiated by test data.

Components that have been evaluated only for design and construction, materials, or both, shall be exempt from this requirement.

8.2.2 Commercial modular manifolds shall have a permanent plate or label affixed in a readily accessible location on the system that shall contain, at a minimum, the following information:

- general system name;
- the statements "Not for residential use. Food service applications only. To be installed by an authorized plumber or an authorized representative of the manufacturer only";
- statement that this modular element is NOT for use in residential applications;
- name and address of manufacturer;
- maximum working pressure in kPa (psig); and

- maximum operating temperature in degrees C (degrees F).

8.2.3 Where applicable and appropriate, the following information shall also be included:

- model number(s) of replacement components;
- electrical requirements;
- statement for activated carbon systems: "Do not use with water that is microbiologically unsafe or of unknown quality without adequate disinfection before or after the system." Additional statement for activated carbon systems claiming cyst reduction: "Systems certified for cyst reduction may be used on disinfected waters that may contain filterable cysts";

NOTE – Where the physical size of the system does not permit affixing the caution statement, the statement shall be prominently displayed in the literature accompanying the system.

- statement for systems claiming VOC reduction: "Conforms to NSF/ANSI 53 for VOC reduction. See performance data sheet for individual contaminants and reduction performance.";

NOTE – Manufacturers may reference individual chemicals from table 16 on labels, manuals, or promotional materials if such information complies with the following:

- percent reductions, if specified, are either less than or equal to those specified in table 10, or additional testing is completed to justify the claim for a higher percent reduction.
- reference to individual chemicals from table 16 shall not imply that specific testing for the chemical was conducted if only the surrogate test was completed.
- for systems claiming radon reduction, the manufacturer's recommended replacement schedule for the carbon filter (to a maximum of one year);
- statement for systems claiming pentavalent arsenic reduction: "Conforms to NSF/ANSI 53 for pentavalent arsenic reduction. See performance data sheet and Arsenic Facts section for an explanation of reduction performance."; and
- statement for systems claiming arsenic reduction: "Conforms to NSF/ANSI 53 for arsenic (pentavalent and trivalent) reduction. See performance data sheet and Arsenic Facts section for an explanation of reduction performance."

8.2.4 Modular elements shall have a permanent plate or label affixed in a readily accessible location on the modular element that shall contain, at a minimum, the following information:

- Modular element model number;
- functional description of modular element (e. g., chemical reduction or mechanical reduction, or both);
- statement that the modular element conforms to NSF/ANSI 42 or 53 for the specific performance claims verified and substantiated by test data;
- statement that this modular element is NOT for use in residential applications; and
- the manufacturer-specific standard head or manifold to which the element can be inserted.

8.2.5 Where applicable and appropriate, the following information shall also be included:

- rated capacity/rated service life in liters (gallons). If applicable rated capacity/rated service life in liters (gallons) is not included on the modular element data plate, a statement indicating that rated capacity/rated service life in liters (gallons) may be found on the performance data sheet shall be included;

NOTE – Each unique model number designation shall not claim a capacity or service life greater than the least reduction capacity or service life that has been verified through testing to NSF/ANSI 42 or 53.

- operating or exchange steps; and
- statement for activated carbon systems: "Do not use with water that is microbiologically unsafe or of unknown quality without adequate disinfection before or after the system."

8.3 Replacement components

8.3.1 The packaging of components specifically for replacement purposes shall be labeled with the following information:

- model number or name of component;
- model number of system(s) in which the component is to be used; and
- name and address of manufacturer.

8.3.2 Where applicable, the following information shall also be stated:

- rated capacity/rated service life in liters (gallons);

NOTE – Each unique model designation shall not claim a capacity or service life greater than the least reduction capacity or service life that has been verified through testing to NSF/ANSI 53.

- operating or exchange steps;
- statement noting that the system(s) conform(s) to NSF/ANSI 53 for the specific performance claims as verified and substantiated by test data;
- statement for systems claiming VOC reduction: "Conforms to NSF/ANSI 53 for VOC reduction. See performance data sheet for individual contaminants and reduction performance.";

NOTE – Manufacturers may reference individual chemicals from table 16 on labels, manuals, or promotional materials if such information complies with the following:

- percent reductions if specified are either less than or equal those specified in table 10 or additional testing is completed to justify the claim for a higher percent reduction.
- reference to individual chemicals from table 16 shall not imply that specific testing for the chemical was conducted if only the surrogate test was completed.
- statement for systems claiming pentavalent arsenic reduction: "Conforms to NSF/ANSI 53 for pentavalent arsenic reduction. See performance data sheet and Arsenic Facts section for an explanation of reduction performance";
- statement for activated carbon systems: "Do not use with water that is microbiologically unsafe or of unknown quality without adequate disinfection before or after the system." Additional statement for activated carbon systems claiming cyst reduction: "Systems certified for cyst reduction may be used on disinfected waters that may contain filterable cysts";

NOTE – Where the physical size of the component does not permit affixing the caution statement, the statement shall be prominently displayed in the literature accompanying the system.

- for systems used in bottled water plants, a statement noting the redundant filtration element sealing mechanism, such as 222 and 226 double o-ring seals;
- for systems claiming radon reduction, the manufacturer's recommended replacement schedule for the carbon filter (to a maximum of one year); and
- statement for systems claiming arsenic reduction: "Conforms to NSF/ANSI 53 for arsenic (pentavalent and trivalent) reduction. See performance data sheet and Arsenic Facts section for an explanation of reduction performance."

8.4 Performance data sheet

8.4.1 A performance data sheet shall be available to potential buyers for each system and shall include the following information:

- complete name, address, and telephone number of manufacturer;
- model number and trade designation;
- statement for claims: "This system has been tested according to NSF/ANSI 53 for reduction of the substances listed below. The concentration of the indicated substances in water entering the system was reduced to a concentration less than or equal to the permissible limit for water leaving the system, as specified in NSF/ANSI 53."

NOTE 1 – Minimum substance reductions per NSF/ANSI 53 shall be listed using the values in tables 16, 17, and 18.

NOTE 2 – In addition to this statement, advertising materials may show the average percent reduction determined during verification.

NOTE 3 – Average concentrations shall be the arithmetic mean of all reported influent challenge or product water concentrations (the detection limit value shall be used for any nondetectable concentrations). The specified percent reduction shall not be greater than the reduction calculated using the arithmetic means of the influent challenge and the product water concentrations respectively.

Annex D ¹⁷
(informative)**Key elements of a certification program
for drinking water treatment systems and components**

A certification program for drinking water treatment systems and components should contain the following program elements.

D.1 Marking the product

Requirements for product marking including:

- certified systems should bear a registered trademark of the certifying organization;
- certified components intended to be used with other components to make a complete functional system, as defined by NSF/ANSI 53, should bear a component mark;
- each system should have a model designation; and
- each system should bear a statement of claims verified through the certifying organization and substantiated by test data.

D.2 Listing certified companies

A published listing of all certified systems and components. The listing format should include at least the following information:

- company name and address;
- product description;
- trademark/model designation;
- flow rate;
- rated capacity or service cycle; and
- each contaminant reduction claim that has been successfully evaluated and is supported by test data.

D.3 Annual audits

Actual physical audits of all facilities and production locations of the certified company at least annually.

¹⁷ The information contained in this annex is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. Therefore, this annex may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the Standard.

D.4 Testing

- testing in accordance with all applicable NSF/ANSI 53 requirements prior to certification; and
- a retest program that includes re-evaluation and retesting at least once every five years.

D.5 Toxicological evaluation of materials formulations

Formulation information of each material used in the fabrication of the system and/or components shall be provided to, and maintained on file by, the certifying organization. The formulation information should include, at a minimum:

- each ingredient's complete chemical identity or proportion by weight;
- each ingredient's sources of supply;
- documentation regarding the health effects concern of each ingredient in the material; and
- documentation regarding the suitability of each ingredient for use in a potable water contact material.

D.6 Corrective action

Corrective action for all items of noncompliance found during audits and re-evaluation, including:

- provisions for review and authorization for modifications to designs;
- modifications to certified system and/or components; and
- documentation and authorization of the modification maintained on file.

D.7 Enforcement

To preserve the integrity of the registered trademark of the certifying organization and protect public health, enforcement action by the certifier for the following:

- use of the registered trademark of the certifying organization on a non-certified product;
- general noncompliance;
- unauthorized change to a certified product;
- unauthorized shipment or disposal of product placed on hold; and
- bribes.

D.8 Administrative review

Provisions for an administrative review as requested by any party directly affected by a decision or action of the certifier.

D.9 Appeals

Provisions for an appeals process as requested by any party directly affected by a decision or action of

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the certifier resulting from an administrative review.

D.10 Complaints

- provisions for investigation of complaints related to certified products, misuse of the registered trademark of the certifying organization by a certified company, and use/misuse of the registered trademark of the certifying organization by a non-certified company; and
- certified company retention and disclosure of complaint records and remedial actions for certified products.

D.11 Advertising

Requirement of proper use of the registered trademark of the certifying organization on sales literature, technical publications, promotional materials, packaging, catalogs, and advertising.

D.12 Records

Provisions for verification of complete certified company records, including:

- installation and service for fabricators and distributors;
- purchased materials and components; and
- production, shipment, and inventory.

D.13 Public notice

Provisions for issuing a public notice for noncompliance with any requirement of certification.

D.14 Confidentiality

A strict policy of non-disclosure of any confidential information supplied to the certifier by the company regarding the product, including formulations, components, processes, ingredients, or the identity of the company's suppliers and distributors.

(19) **United States**(12) **Patent Application Publication****Rinker et al.**(10) **Pub. No.: US 2006/0000763 A1**(43) **Pub. Date:****Jan. 5, 2006**(54) **GRAVITY FLOW CARBON BLOCK FILTER****Publication Classification**

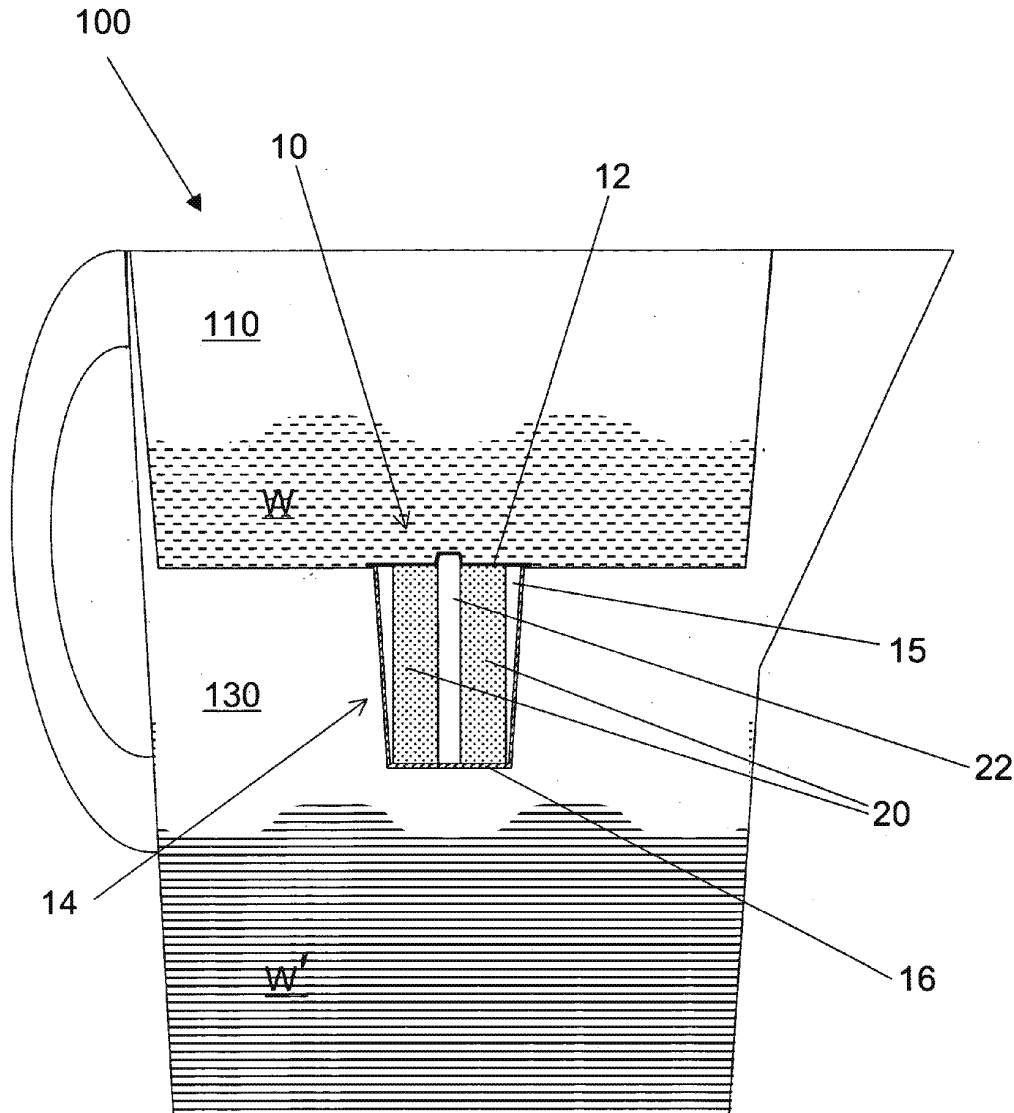
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(51) **Int. Cl.**
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(52) **U.S. Cl.** **210/282; 210/502.1**

(57) **ABSTRACT**

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A gravity flow carbon block filter comprising approximately 20-90 wt % activated carbon particles having a mean particle size in the range of approximately 90-220 μm , and approximately 10-50 wt % low melt index polymeric material. The low melt index polymeric material can have a melt index less than 1.0 g/10 min or greater than 1.0 g/10 min and a mean particle size in the range of approximately 20-150 μm .

(21) Appl. No.: **10/881,517**(22) Filed: **Jun. 30, 2004**

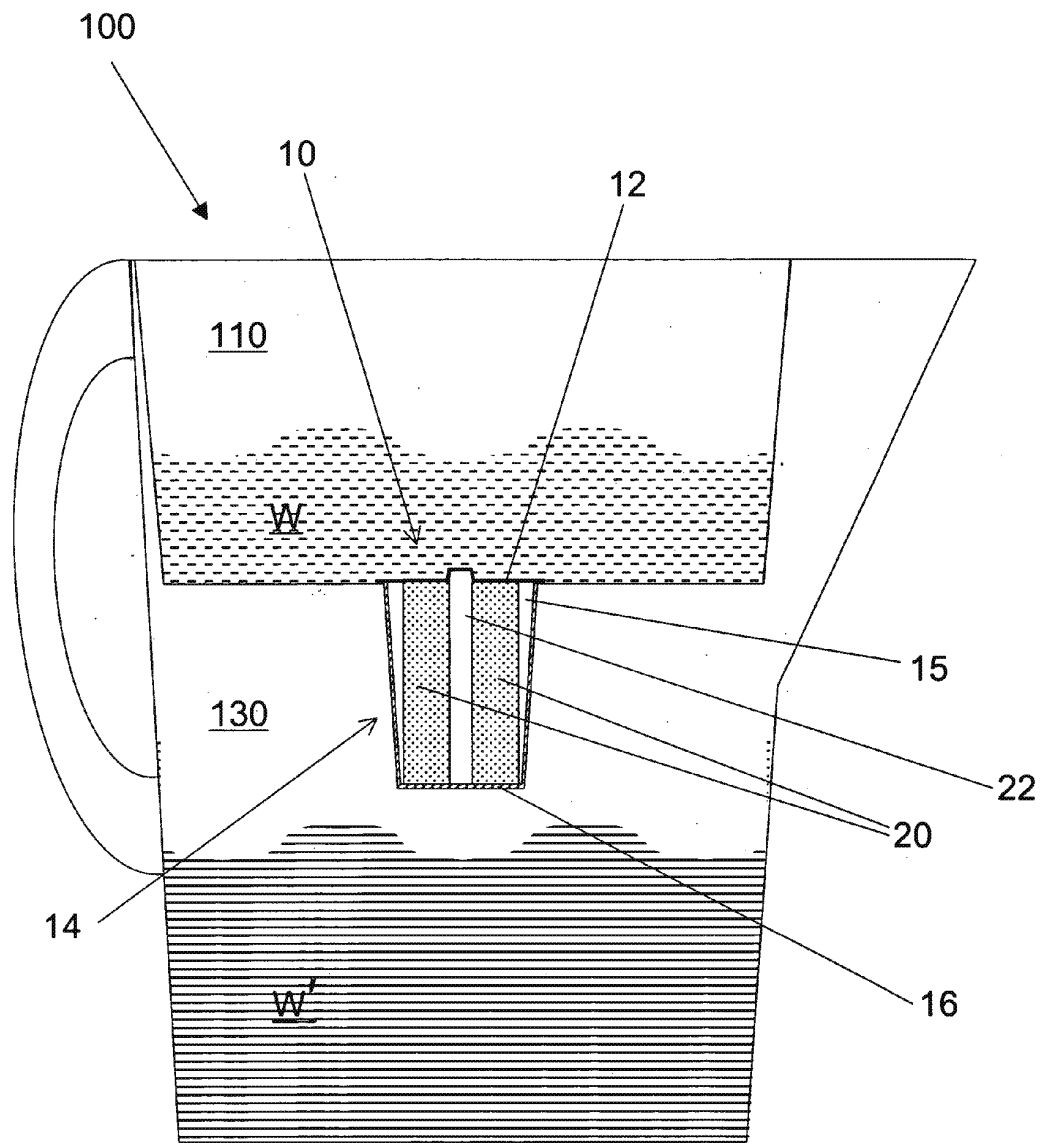


FIG. 1

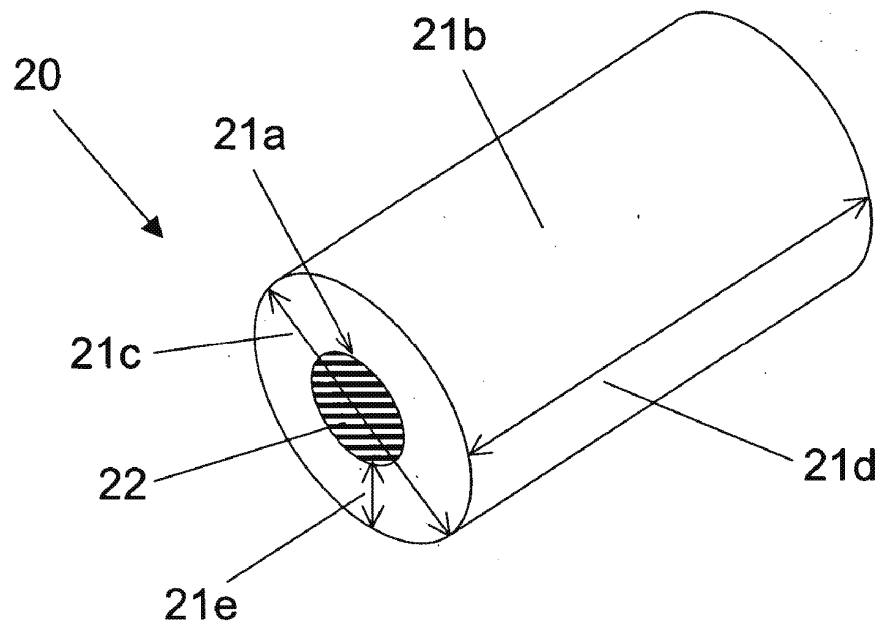


FIG. 2

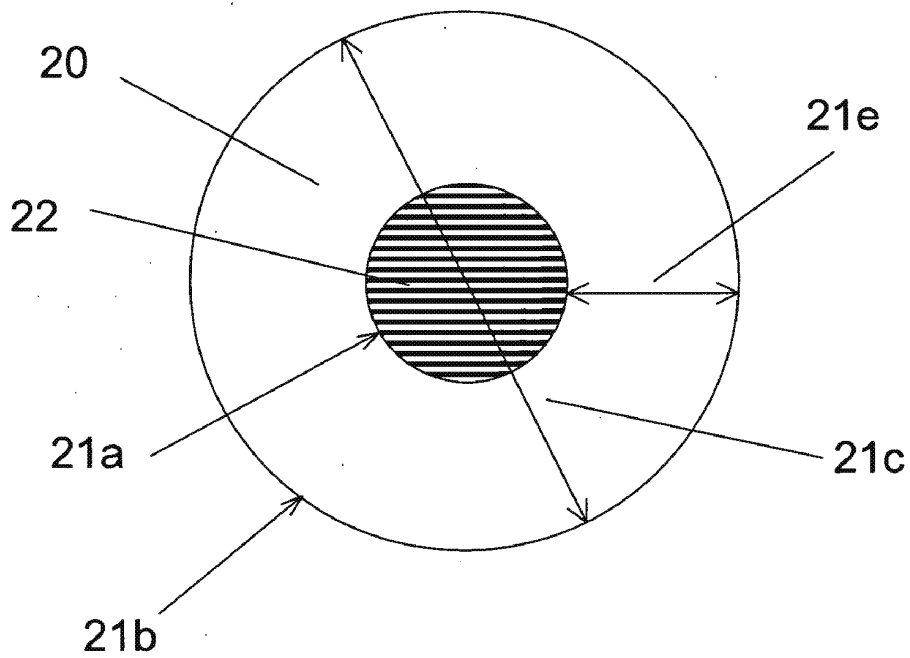


FIG. 3

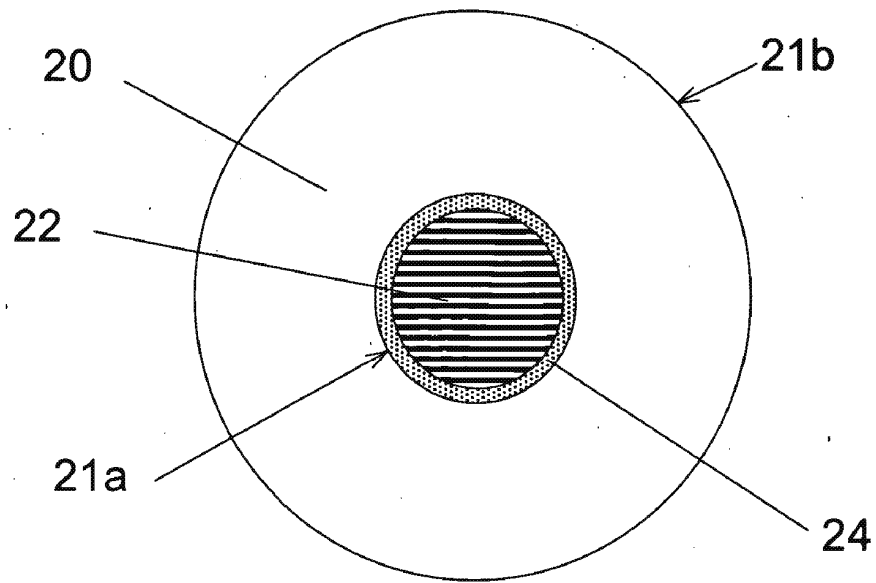


FIG. 4

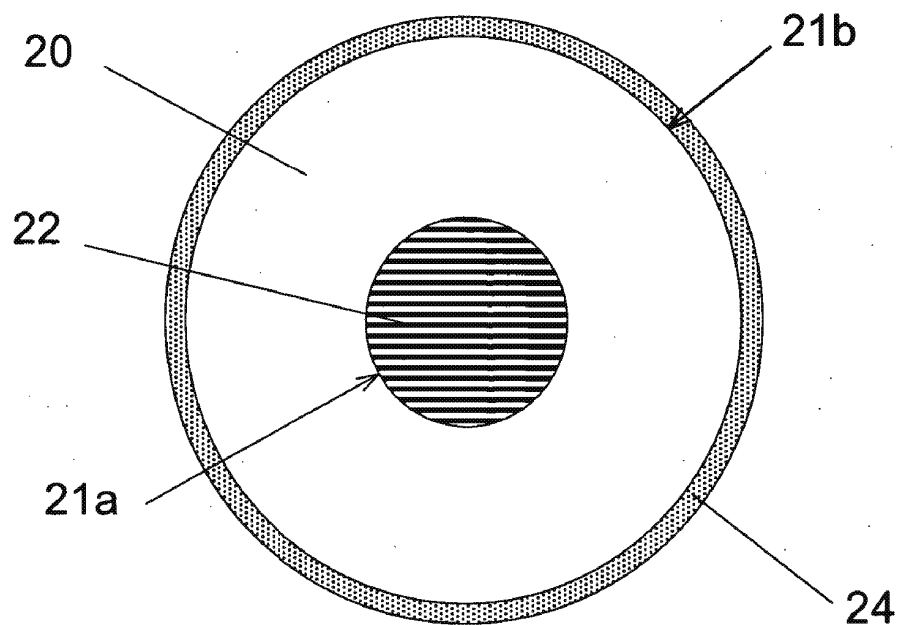


FIG. 5

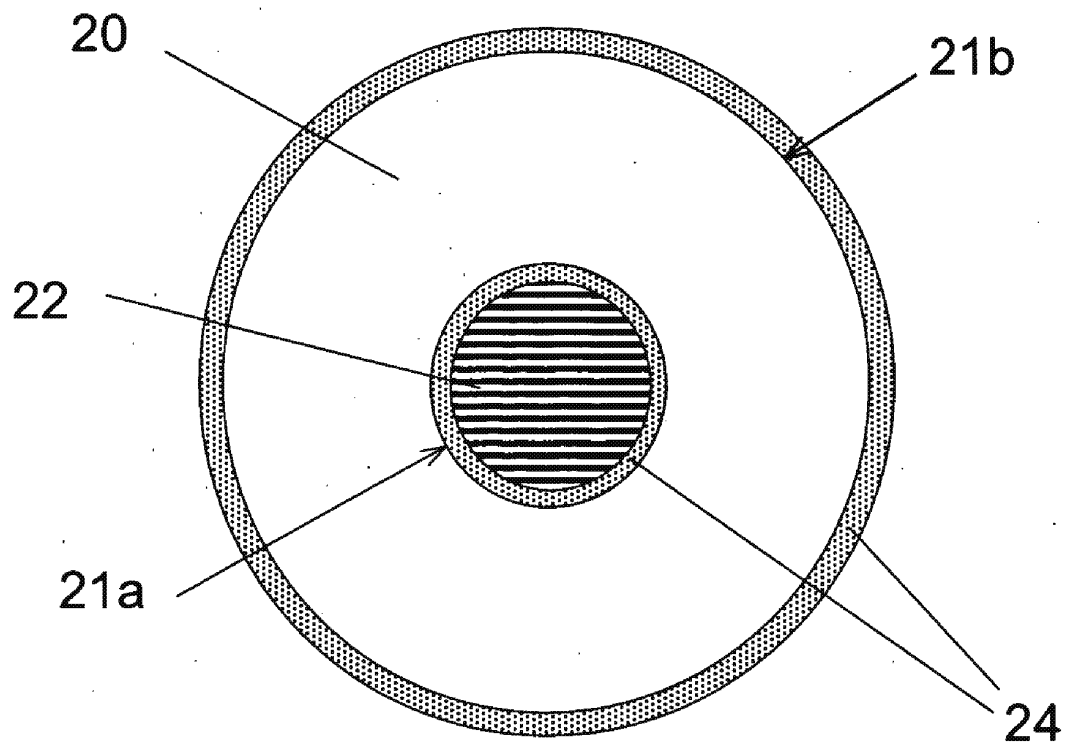


FIG. 6

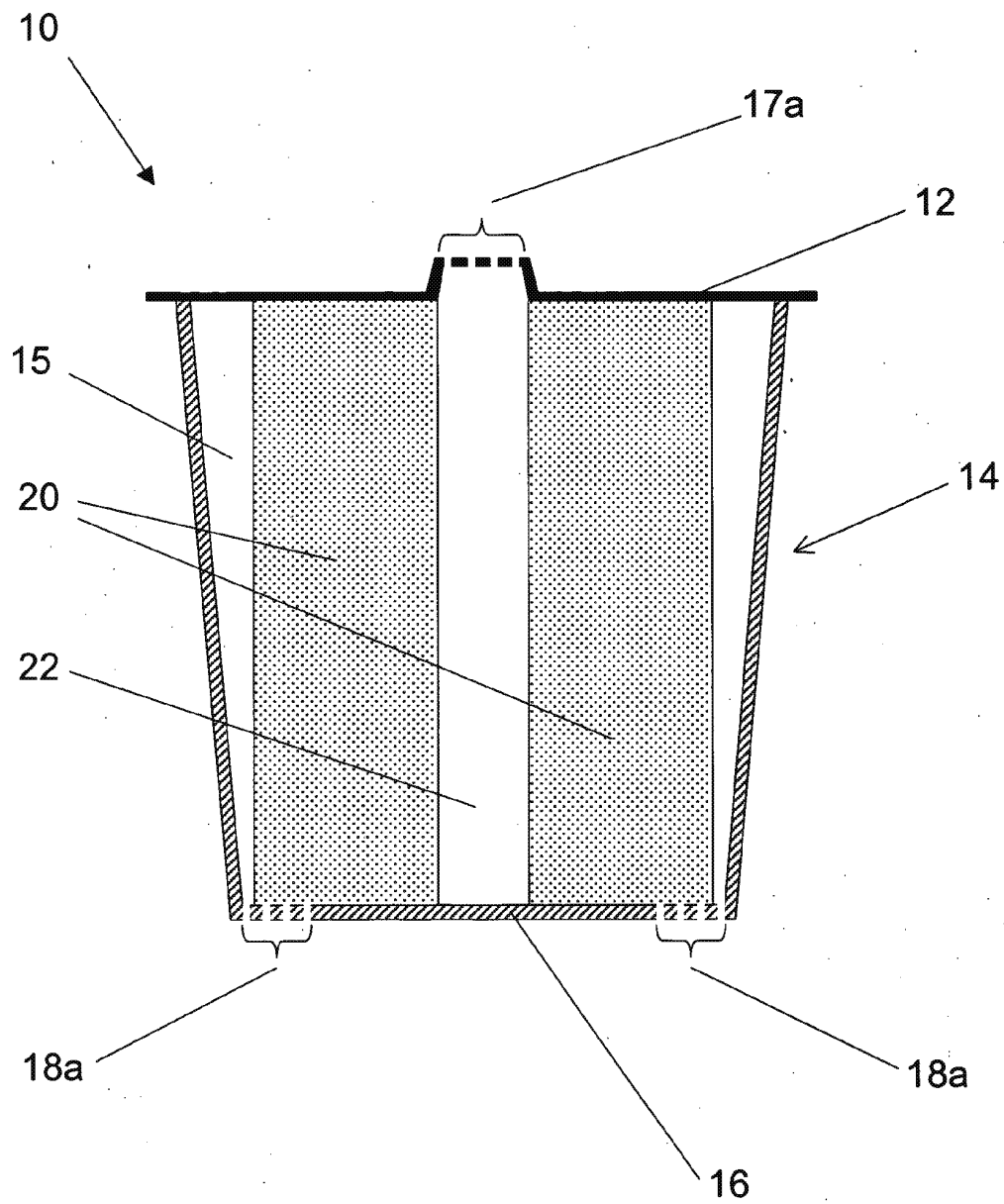


FIG. 7

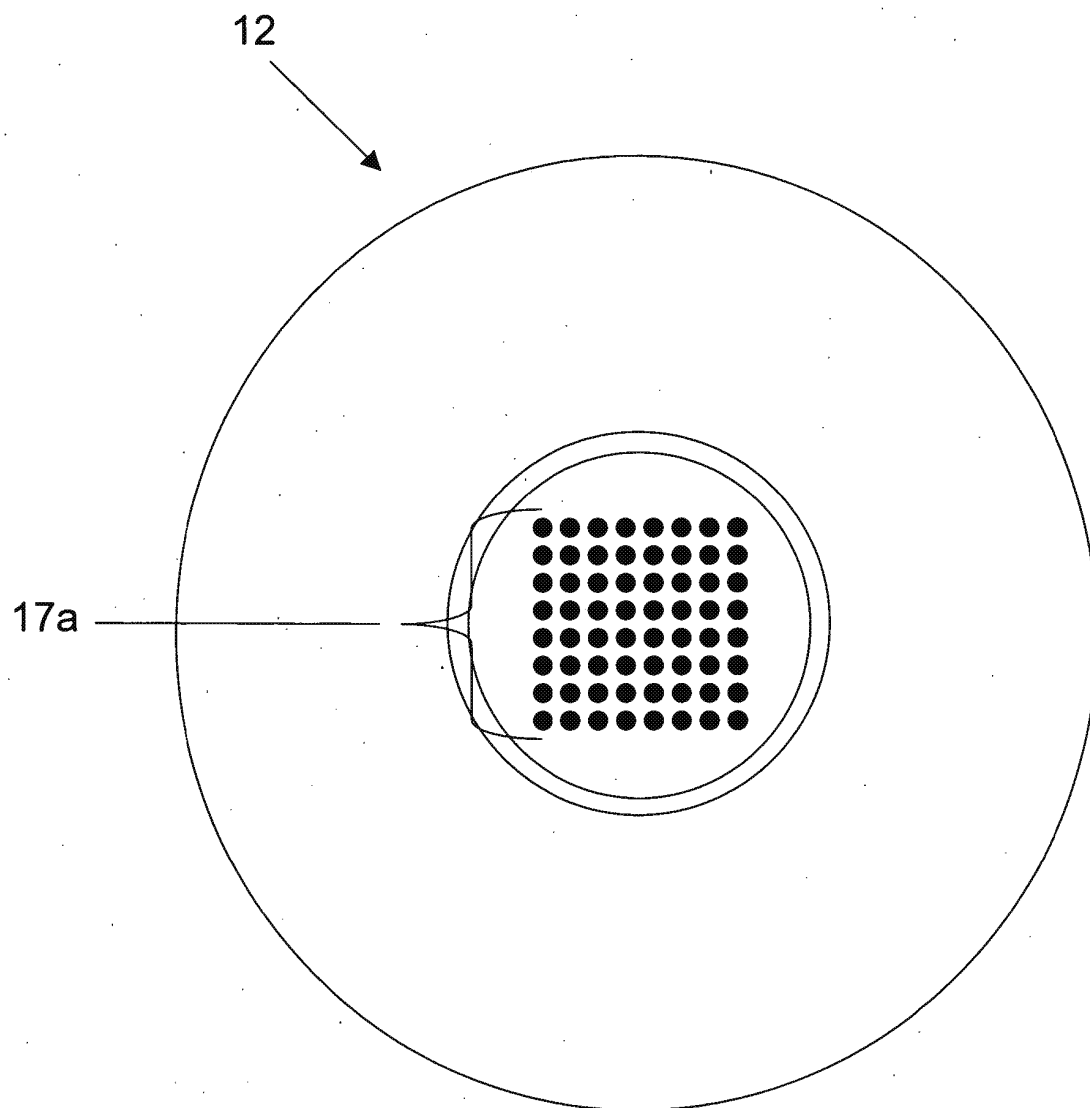


FIG. 8

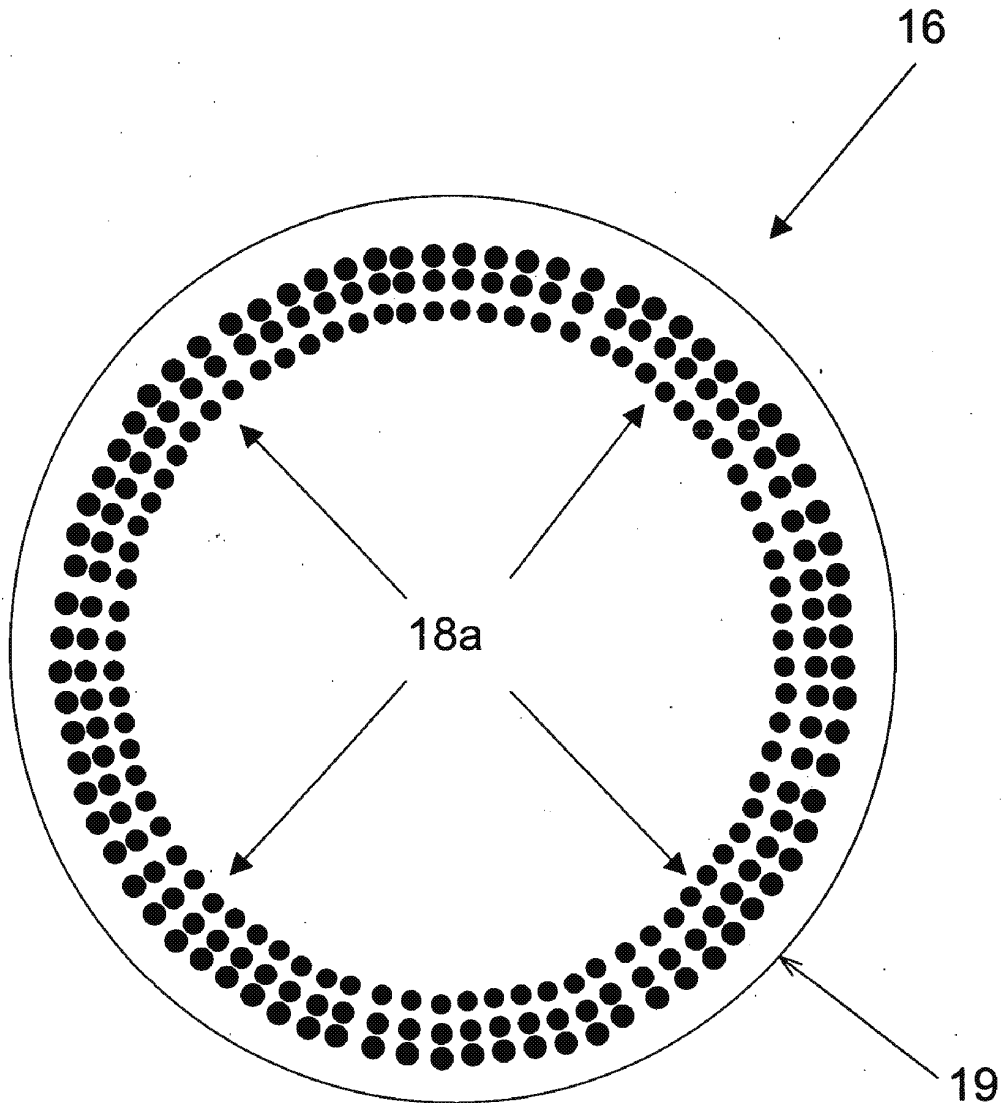


FIG. 9

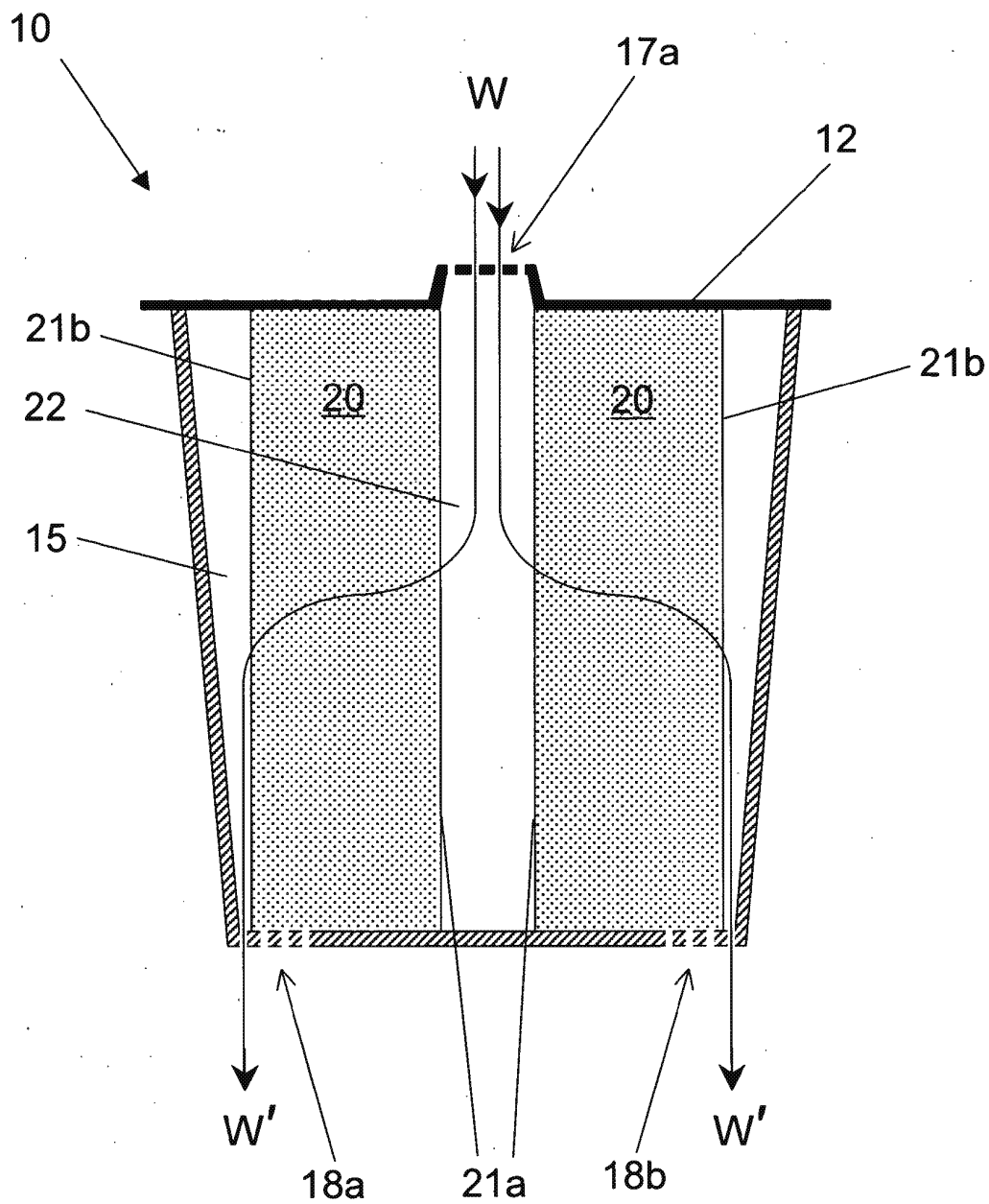


FIG. 10

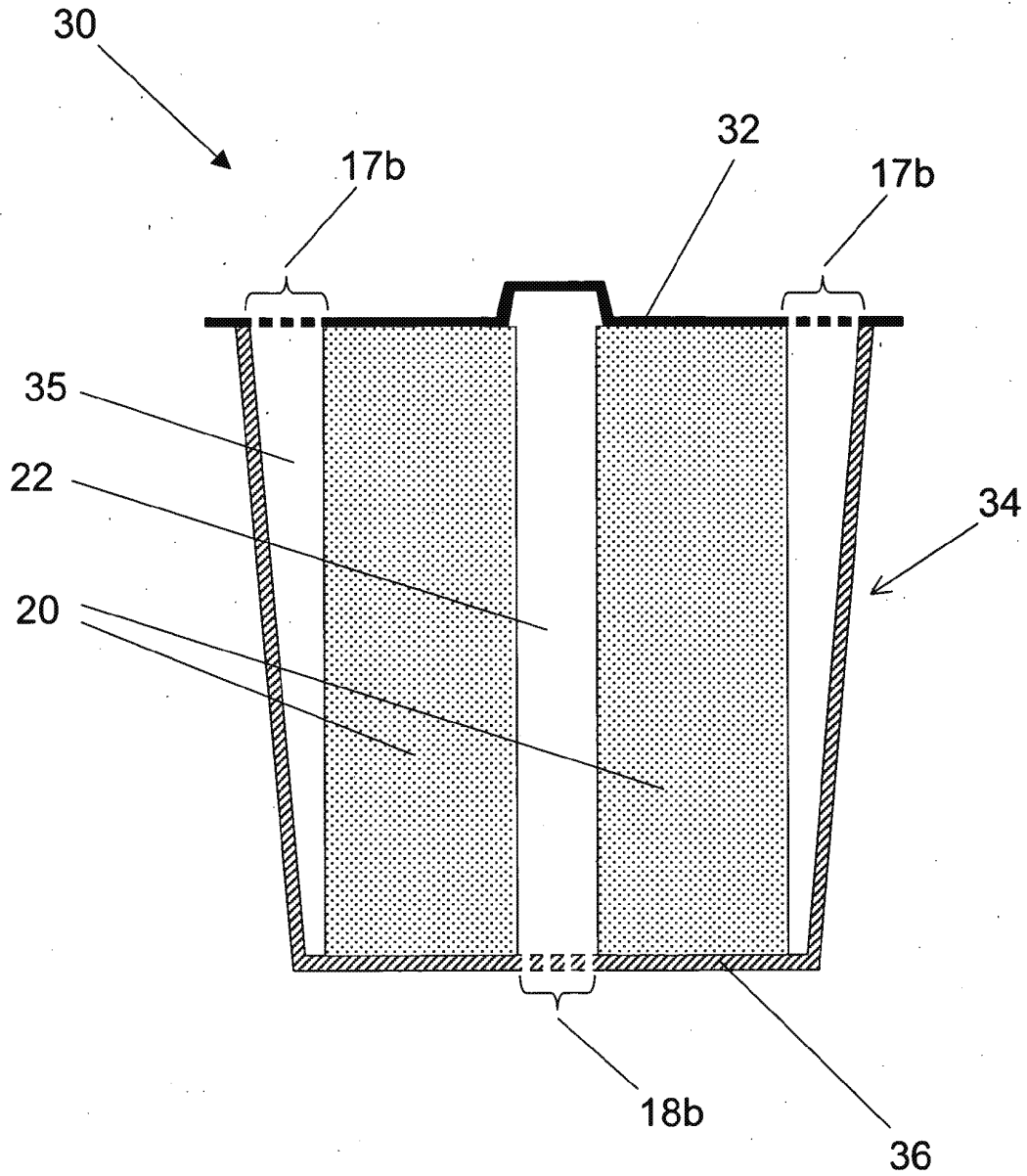


FIG. 11

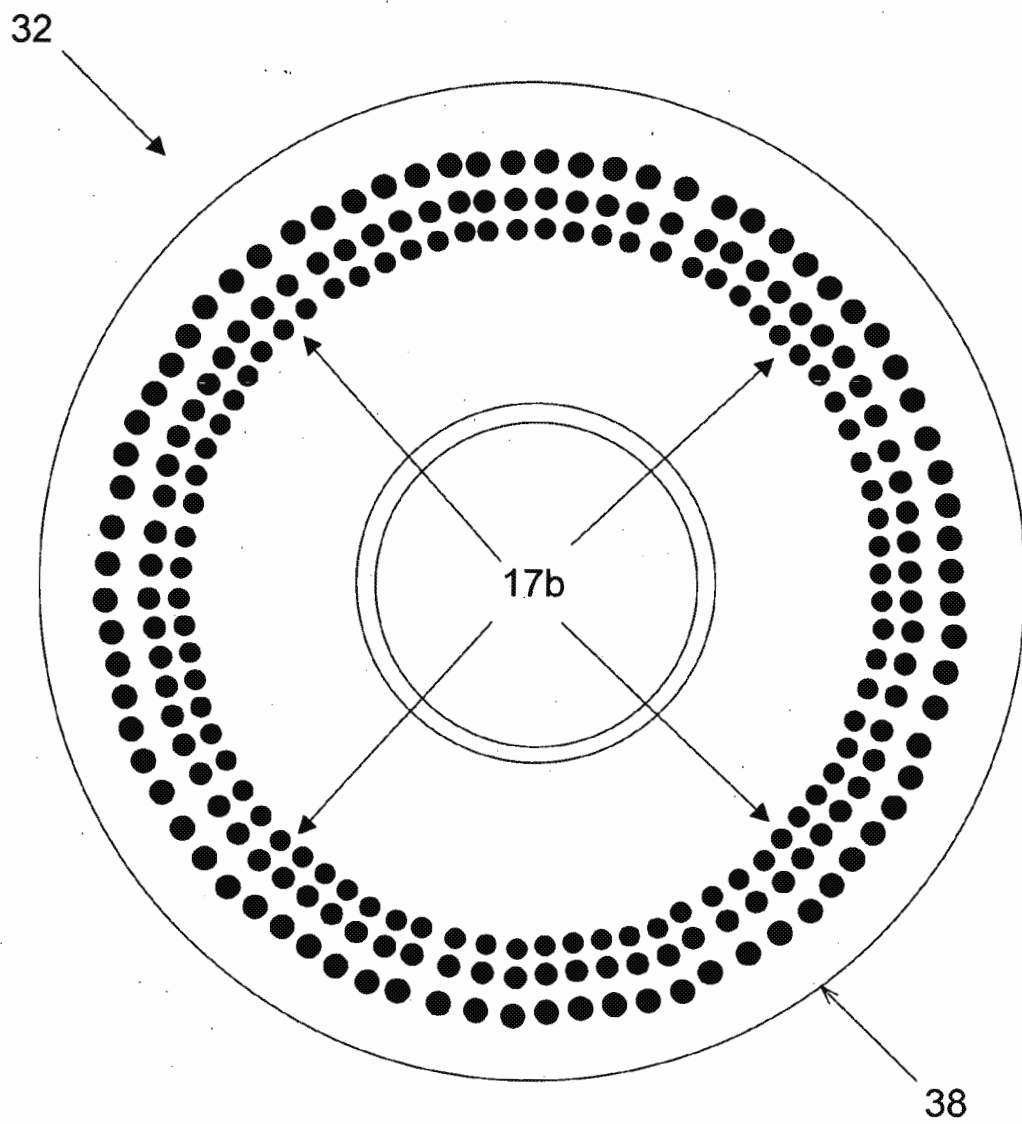


FIG. 12

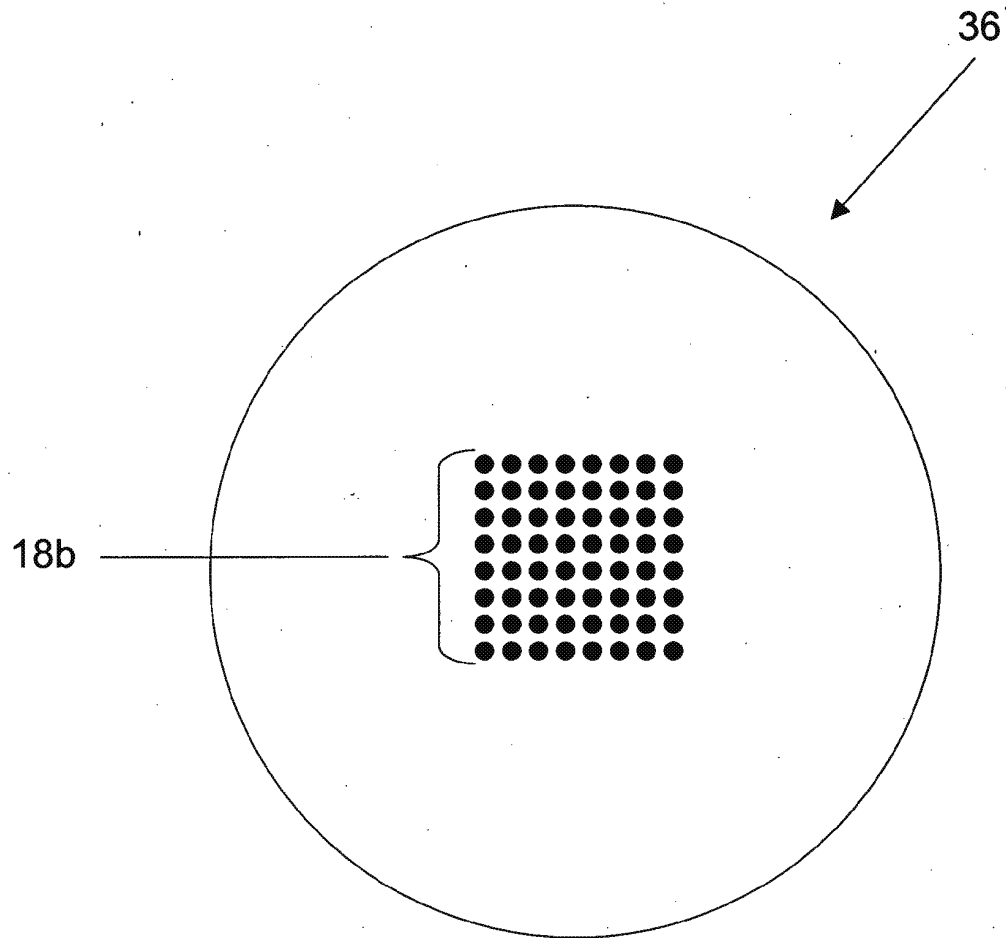


FIG. 13

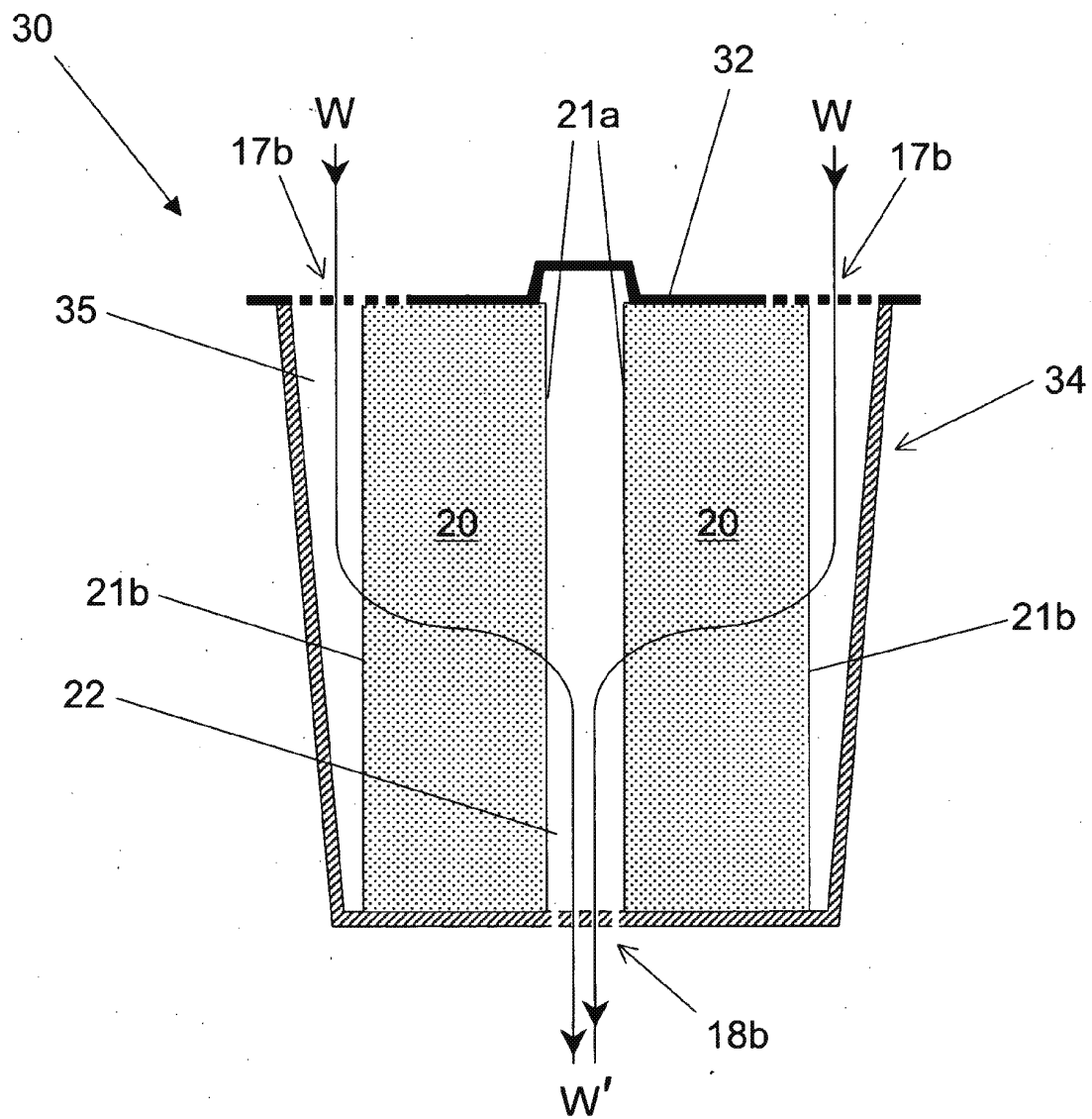


FIG. 14

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GRAVITY FLOW CARBON BLOCK FILTER**FIELD OF THE INVENTION**

[0001] The present invention relates generally to gravity flow filtration systems. More particularly, the invention relates to an improved gravity flow carbon block filter that exhibits a rapid flow rate and high contaminant reduction.

BACKGROUND

[0002] Gravity flow filtration systems are well known in the art. Such systems include pour-through carafes and refrigerator water tanks, which have been developed by The Clorox Company (BRITA®), Culligan™, Rubbermaid™ and Glacier Pure™.

[0003] Pour-through carafe systems typically include an upper reservoir for receiving unfiltered water, a lower reservoir for receiving and storing filtered water, and a filtration cartridge with an inlet at its top and outlet at its bottom, through which cartridge, water flows from the upper reservoir to the lower reservoir. The pour-through carafe is sized to be handheld, holds about two liters of water, and may be tipped for pouring filtered water, as in a conventional pitcher or carafe.

[0004] Refrigerator tank systems typically include a larger rectangular tank with a spigot for draining filtered water into a glass or pan. Both carafe and refrigerator tank systems use gravity to move the unfiltered water in the top reservoir down through a filtration cartridge and into the lower reservoir where the filtered water remains until it is used.

[0005] The filtration cartridge typically employed in pour-through (or gravity flow) systems holds blended media of approximately 20×50 mesh granular activated carbon and either an ion exchange resin, which most typically contains a weak acid cation exchange resin, or a natural or artificial zeolite that facilitates the removal of certain heavy metals, such as lead and copper. Weak acid cation exchange resins can reduce the hardness of the water slightly, and some disadvantages are also associated with their use: first, they require a long contact time to work properly, which limits the flow rate to about one-third liter per minute; second, they take up a large amount of space inside the filter (65% of the total volume) and thus limit the space available for activated carbon.

[0006] A further problem associated with blended media of granular carbon and ion exchange resin is that they have limited contaminant removal capability due to particle size and packing geometry of the granules. When large granules are packed together, large voids can form between the granules. As water passes through the packed filter bed, it flows through the voids. Much of the water in the voids does not come into direct contact with a granule surface where contaminants can be adsorbed. Contaminant molecules must diffuse through the water in the voids to granule surfaces in order to be removed from the water. Thus, the larger the voids, the larger the contaminant diffusion distances. In order to allow contaminants to diffuse over relatively long distances, long contact time is required for large granular media to remove a significant amount of contaminant molecules from the water.

[0007] Conversely, small granules (i.e., 100-150 μm) form small voids when packed together, and contaminants in

water within the voids have small distances over which to diffuse in order to be adsorbed on a granule surface. As a result, shorter contact time between the water and the filter media is required to remove the same amount of contaminant molecules from the water for filter media with small granules than for filter media with large granules.

[0008] But there are some drawbacks to using filter media with small granules. Water flow can be slow because the packing of the granules can be very dense, resulting in long filtration times. Also, small granules can be more difficult to retain within the filter cartridge housing.

[0009] It would be useful to have a gravity flow filter that exhibits both good water flow rates and high containment reduction.

SUMMARY

[0010] A gravity flow filter block comprising approximately 20-90 wt % activated carbon particles having a mean particle size in the range of approximately 90-220 μm , and approximately 10-50 wt % binder material is provided. The binder material can have a melt index less than 1.0 g/10 min or greater than 1.0 g/10 min and a mean particle size in the range of approximately 20-150 μm .

[0011] In one embodiment of the invention, the activated carbon particles are impregnated with either citric acid, a hydroxide, a metal, metal oxide, a metal ion or a salt.

[0012] In another embodiment of the invention, the filter contains approximately 10-80 wt % activated carbon particles having a mean particle size in the range of approximately 90-220 μm , approximately 10-50 wt % binder material and approximately 5-40 wt % of an active material. The active material can contain ceramic, zeolite or alumina particles having a mean particle size in the range of approximately 20-100 μm or silica gel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Further features and advantages will become apparent from the following and more particular description of the embodiments of the invention, as illustrated in the accompanying drawings, and in which like referenced characters generally refer to the same parts or elements throughout the views, and in which:

[0014] **FIG. 1** is a cross-section, side elevation view of a pour-through carafe having a gravity-flow filtration cartridge with a carbon block filter installed therein.

[0015] **FIG. 2** is a perspective view of one embodiment of a carbon block filter.

[0016] **FIG. 3** is a top plan view of the carbon block filter shown in **FIG. 2**.

[0017] **FIG. 4** is a top plan view of a carbon block filter having a filter sheet disposed proximate the inner wall.

[0018] **FIG. 5** is a top plan view of a carbon block filter having a filter sheet disposed proximate the outer wall.

[0019] **FIG. 6** is a top plan view of a carbon block filter having a first filter sheet disposed proximate the inner wall and a second filter sheet disposed proximate the outer wall.

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[0020] FIG. 7 is a cross-section, side elevation view of an embodiment of a filtration cartridge with a carbon block filter installed therein.

[0021] FIG. 8 is a top plan view of the filtration cartridge cover shown in FIG. 7.

[0022] FIG. 9 is a bottom plan view of the filtration cartridge cup shown in FIG. 7.

[0023] FIG. 10 is a cross-section, side elevation view of an outward water flow path through the filtration cartridge assembly shown in FIG. 7.

[0024] FIG. 11 is a cross-section, side elevation view of an embodiment of a filtration cartridge having a carbon block filter installed therein.

[0025] FIG. 12 is a top plan view of the filtration cartridge cover shown in FIG. 11.

[0026] FIG. 13 is a bottom plan view of the filtration cartridge cup shown in FIG. 11.

[0027] FIG. 14 is a cross-section, side elevation view of an inward water flow path through the filtration cartridge shown in FIG. 11.

DETAILED DESCRIPTION

[0028] Before describing the embodiments in detail, it is to be understood that this invention is not limited to particularly exemplified structures, systems or system parameters, as such may, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments of the invention only, and is not intended to be limiting.

Definitions

[0029] In describing the embodiments of the present invention, the following terms will be employed, and are intended to be defined as indicated below.

[0030] The term "activated carbon," as used herein, means highly porous carbon having a random or amorphous structure. The term "activated carbon" thus includes, but is not limited to, carbon derived from bituminous or other forms of coal, pitch, bones, nut shells, coconut shells, corn husks, polyacrylonitrile (PAN) polymers, charred cellulosic fibers or materials, wood, and the like.

[0031] The term "binder," as used herein, means a material that promotes cohesion of aggregates or particles. The term "binder" thus includes polymeric and/or thermoplastic materials that are capable of softening and becoming "tacky" at elevated temperatures and hardening when cooled. Such thermoplastic binders include, but are not limited to, end-capped polyacetals, such as poly(oxymethylene) or poly-formaldehyde, poly(trichloroacetaldehyde), poly(n-valeraldehyde), poly(acetaldehyde), poly(propionaldehyde), and the like; acrylic polymers, such as polyacrylamide, poly(acrylic acid), poly(methacrylic acid), poly(ethyl acrylate), poly(methyl methacrylate), and the like; fluorocarbon polymers, such as poly(tetrafluoroethylene), perfluorinated ethylene-propylene copolymers, ethylene-tetrafluoroethylene copolymers, poly(chlorotrifluoroethylene), ethylene-chlorotrifluoroethylene copolymers, poly(vinylidene fluoride), poly(vinyl fluoride), and the like; polyamides, such as poly(6-aminocaproic acid) or poly(epsilon-caprolactam),

poly(hexamethylene adipamide), poly(hexamethylene sebacamide), poly(11-aminoundecanoic acid), and the like; polyaramides, such as poly(imino-1,3-phenyleneiminoisophthaloyl) or poly(m-phenylene isophthalamide), and the like; parylenes, such as poly-p-xylylene, poly(chloro-p-xylylene), and the like; polyaryl ethers, such as poly(oxy-2,6-dimethyl-1,4-phenylene) or poly(p-phenylene oxide), and the like; polyaryl sulfones, such as poly(oxy-1,4-phenylenesulfonyl-1,4-phenyleneoxy-1,4-phenylene-isopropylidene-1,4-phenylene), poly-(sulfonyl-1,4-phenyleneoxy-1,4-phenylenesulfonyl-4,4'-biphenylene), and the like; polycarbonates, such as poly(bisphenol A) or poly(carbon-yldioxy-1,4-phenyleneisopropylidene-1,4-phenylene), and the like; polyesters, such as poly(ethylene terephthalate), poly(tetramethylene terephthalate), poly(cyclohexylene-1,4-dimethylene terephthalate) or poly(oxymethylene-1,4-cyclohexylenemethyleneoxyterephthaloyl), and the like; polyaryl sulfides, such as poly(p-phenylene sulfide) or poly(thio-1,4-phenylene), and the like; polyimides, such as poly(pyromellitimido-1,4-phenylene), and the like; polyolefins, such as polyethylene, polypropylene, poly(1-butene), poly(2-butene), poly(1-pentene), poly(2-pentene), poly(3-methyl-1-pentene), poly(4-methyl-1-pentene), and the like; vinyl polymers, such as poly(vinyl acetate), poly(vinylidene chloride), poly(vinyl chloride), and the like; diene polymers, such as 1,2-poly-1,3-butadiene, 1,4-poly-1,3-butadiene, polyisoprene, polychloroprene, and the like; polystyrenes; copolymers of the foregoing, such as acrylonitrile-butadiene-styrene (ABS) copolymers, and the like; and the like.

[0032] The thermoplastic binders further include ethylenevinyl acetate copolymers (EVA), ultra-high molecular weight polyethylene (UHMWPE), very high molecular weight polyethylene (VHMWPE), nylon, polyethersulfone, ethylene-acrylic acid copolymer, ethylene-methacrylic acid copolymer, ethylene-methylacrylate copolymer, polymethylmethacrylate, polyethylmethacrylate, polybutylmethacrylate, and copolymers/mixtures thereof.

[0033] The term "low melt index polymeric material," as used herein, means a polymeric material having a melt index less than 1.0 g/10 min., as determined by ASTM D 1238 at 190° C. and 15 kg load. The term thus includes both ultra high and very high molecular weight polyethylene.

[0034] The terms "cationically charged" and "cationic," as used herein, mean having a plurality of positively charged groups. The terms "cationically charged" and "positively charged" are thus synonymous and include, but are not limited to, a plurality of quaternary ammonium groups.

[0035] The term "functionalized," as used herein, means including a plurality of functional groups (other than the cationic groups) that are capable of crosslinking when subjected to heat. Such functional groups include, but are not limited to, epoxy, ethylenimine and episulfido. The term "functionalized cationic polymer" thus means a polymer that contains a plurality of positively charged groups and a plurality of at least one further functional group that is capable of being crosslinked by the application of heat. Such polymers include, but are not limited to, epichlorohydrin-functionalized polyamines and epichlorohydrin-functionalized polyamido-amines.

[0036] The term "incorporating," as used herein, means including, such as including a functional element of a device, apparatus or system. Incorporation in a device may

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be permanent, such as a non-removable filter cartridge in a disposable water filtration device, or temporary, such as a replaceable filter cartridge in a permanent or semi-permanent water filtration device.

[0037] Filter performance can be defined in various ways. For the purposes of the instant invention, good filter performance means some or all of the following:

[0038] Removal of at least 99.95% of particles greater than 3 μm in size from the source water until the water flow rate has been reduced by approximately 75% from an initial water flow rate;

[0039] Reduction of lead concentration to no more than 10 ppb in 100 gallons of source water that has an initial lead concentration of 150 ppb;

[0040] Reduction of chloroform concentration to no more than 80 ppb in 100 gallons of source water that has an initial chloroform concentration of 450 ppb.

[0041] In general, water moves through gravity flow water filters with head pressures less than 1 psi. Good flow rates for gravity flow water filters with head pressures in this range are rates faster than about 0.20 liters/min (or about 0.05 gallons/min). In general, conventional, loose media, gravity-flow carbon filters have flow rates between about 0.125 liters/minute and 0.250 liters/minute. Conventional carbon block filters vary in their flow rate performance and, as they are usually used in faucet-mount systems, are subject to wider ranges of head pressure due to variations in household water pressures than are loose media filters. Typical carbon block filters can have flow rates around 3.5 liters/min (or about 0.75 gallons/min) with head pressures around 60 psi. In general, water does not flow through most block filters under the low pressure (less than 1 psi) conditions found in gravity flow systems.

[0042] As will be appreciated by one having ordinary skill in the art, the gravity flow filters described herein have many advantages. In one embodiment of the invention, the filter, described in detail below, generally contains approximately 20-90 wt % activated carbon particles having a mean particle size in the range of approximately 90-220 μm , and approximately 10-50 wt % low melt index polymeric material (i.e., binder). The low melt index polymeric material can have a melt index less than 1.0 g/10 min. at 190° C. and 15 kg load and a mean particle size in the range of approximately 20-150 μm .

[0043] In another embodiment of the invention, the filter contains approximately 10-80 wt % activated carbon particles having a mean particle size in the range of approximately 90-220 μm , approximately 10-50 wt % low melt index polymeric material and approximately 5-40 wt % of an active material. The active material can contain ceramic, zeolite or alumina particles, each having a mean particle size in the range of approximately 20-100 μm , or silica gel.

[0044] Referring first to FIG. 1, there is a filter cartridge 10 installed in a pour-through water carafe 100. The filter cartridge 10 has a carbon block filter 20 inside. In operation, source water W flowing from upper reservoir 110 to lower reservoir 130 is channeled through a plurality of openings (not shown) in cover 12, directly into interior space 15 of filter cup 14. Inorganic and organic contaminants are removed from the source water W, as the source water W

moves through the filter 20, thus transforming the source water W into filtered water W'. The filtered water W' flows into cavity 22 of the filter 20 and out through bottom 16 of the filter cup 14 into lower reservoir 130.

[0045] In an alternative embodiment, source water W flowing from the upper reservoir 110 to the lower reservoir 130 is channeled through a plurality of openings (not shown) in the cover 12, directly into the filter cavity 22. Inorganic and organic contaminants are removed from the source water W, as the source water W moves through the filter 20, thus transforming the source water W into filtered water W'. The filtered water W' flows from the filter 20 directly out through the bottom 16 of the filter cup 14 and into the lower reservoir 130.

[0046] Although a pour-through carafe has been used to illustrate the filter 20, the filter 20 can be employed in combination with any water pitcher, bottle, carafe, tank, or other gravity-flow filtration system. The embodiments of the invention should thus not be construed as being limited in scope to filtering water only in pour-through carafes.

[0047] The filter 20 can contain activated carbon that is bonded with a binder to form an integrated, porous, composite, carbon block. The activated carbon can be in the form of particles or fibers. In some embodiments, the filter 20 includes at least one additional active material, such as ceramic or zeolite particles. The active material(s) can also be bound together with the carbon and the binder within the porous composite block.

Activated Carbon

[0048] Activated carbon from any source can be used, such as that derived from bituminous coal or other forms of coal, or from pitch, bones, nut shells, coconut shells, corn husks, polyacrylonitrile (PAN) polymers, charred cellulosic fibers or materials, wood, and the like. Activated carbon granules can, for example, be formed directly by activation of coal or other materials, or by grinding carbonaceous material to a fine powder, agglomerating it with pitch or other adhesives, and then converting the agglomerate to activated carbon. Coal-based or wood-based activated carbon can be used in combination or separately, e.g., 90% coconut carbon and 10% bituminous carbon.

[0049] In one embodiment of the invention, the mesh size of the activated carbon is approximately 80 \times 325 U.S. mesh. In another embodiment of the invention, the mesh size of the activated carbon is approximately 80 \times 200 U.S. mesh. As reflected in the "Examples" section, although the 80 \times 200 mesh size is less effective in removing contaminants from water than the 80 \times 325 mesh carbon, the 80 \times 200 mesh exhibits a higher filtration rate.

[0050] In yet another embodiment of the invention, the mesh size of the activated carbon is approximately 50 \times 200 U.S. mesh. As also reflected in the "Examples" section, the noted mesh size exhibits excellent effectiveness in removing contaminants from water and a very high filtration rate.

[0051] In some arrangements, the activated carbon has an average particle size such that it can pass through a screen of 350 mesh or less (e.g., an average particle size of less than about 350 mesh-about 40 μm). In one arrangement, the activated carbon has a mean particle size in the range of

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90-220 μm . In another arrangement, the activated carbon has a mean particle size in the range of 150-200 μm .

[0052] The activated carbon can also be impregnated or coated with other materials to increase the adsorption of specific species. For example, the activated carbon can be impregnated with citric acid to increase the ability of the activated carbon to adsorb ammonia. Impregnation of the active carbon with hydroxides, such as sodium hydroxide, or other caustic compounds can also be useful for removal of hydrogen sulfide.

[0053] Impregnation of the activated carbon with metals, metal oxides, metal hydroxides or metal ions, such as copper sulfate and copper chloride, is believed to be useful for removal of other sulfur compounds. Finally, the activated carbon can also be impregnated with a variety of salts, such as zinc salts, potassium salts, sodium salts, silver salts, and the like. In other arrangements, activated carbon can be modified with reduced nitrogen groups, metal oxides, or other metal compounds suitable for removal of contaminants from water.

[0054] In another embodiment of the invention, the carbon content is in the range of approximately 20-90%, by weight. In an alternative embodiment, the carbon content is in the range of approximately 40-80%, by weight. When other actives are included in the filter **20**, the carbon content can be in the range of approximately 10-80%, by weight.

Binder

[0055] The binder can contain any of the aforementioned binder materials. The binder can be a low melt index polymeric material, as described above. In other arrangements, the binder can contain a higher melt index material, that is, a material with a melt index that is greater than 1.0 g/10 min.

[0056] Low melt index polymeric materials having a melt index less than approximately 1.0 g/10 min at 190° C. and 15 kg load, such as VHMWPE or UHMWPE, are well known in the art. Low melt index binders do not flow easily when heated, but become only tacky enough to bind granules together without covering much of the surface of the granules.

[0057] In some arrangements, binder materials that have high melt index values, that is, melt indices greater than those of VHMWPE or UHMWPE, such as poly(ethylene-co-acrylic acid) or low density polyethylene, can also be used. Even though high melt index materials can tend to melt and flow when heated, careful choice of binder particle size and processing conditions can make these materials very effective for forming porous composite blocks for water filtration. These binders and their use in water filtration have been disclosed by Taylor et al. in U.S. patent application Ser. No. 10/756,478, filed Jan. 12, 2004, which is included by reference herein.

[0058] As will be appreciated by one having ordinary skill in the art, the type of binder used to construct the filter **20** can affect the initial flow rate of water through the filter, since carbon is more hydrophilic than most binders or other actives. Initially, the filter **20** is dry and when it is placed in contact with water, it may or may not absorb the water readily and thus allow for immediate water flow. Filters made with UHMWPE or VHMWPE with a low melt index

tend to absorb water more readily than filters made with EVA or LDPE. Also, by maximizing the available surface area of the carbon, one can achieve a carbon block that is hydrophilic and readily absorbs water. As a result, binders that neither flow nor deform significantly when melted, but simply become tacky, maximize the available carbon surface area and thus maximize the water absorptivity of the carbon block. Other binders that have a tendency to melt during processing can also provide a large available carbon surface area when they have very small particle sizes. As discussed in detail in the "Examples" section, this phenomenon has been confirmed by measuring the iodine number and strike-through of carbon blocks made with different binders.

[0059] In one embodiment, the binder content is in the range of approximately 5-50%, by weight. In other arrangements, the binder content is in the range of approximately 20-35%, by weight.

[0060] In one embodiment of the invention, the binder particles are in the range of approximately 5-150 μm . In an alternative embodiment, the binder particles are in the range of approximately 100-150 μm . In another embodiment, the binder particles are approximately 110 μm .

Actives

[0061] One or more additional active materials (or actives) can be included in the carbon block filter. The active(s) can contain ceramic particles, zeolite particles, zirconia, aluminosilicate, silica gel, alumina, metal oxides/hydroxides, inert particles, sand, surface charge-modified particles, clay, pyrolyzed ion-exchange resin and mixtures thereof.

[0062] In one embodiment, the actives constitute between about 0.01 wt % and 70 wt % of the porous composite block. In other arrangements, the actives constitute between about 20 wt % and 40 wt % of the porous composite block. In another arrangement, the actives constitute between about 5% and 40%, by weight, of the porous composite block. In another arrangement, the actives constitute between about 10% and 30%, by weight, of the porous composite block.

[0063] In one embodiment of the invention, the actives have a mean particle size in the range of approximately 20 to 100 μm . In an alternative embodiment, the actives have a mean particle size in the range of approximately 1 to 50 μm .

Filter Block Dimensions

[0064] As illustrated in **FIGS. 2 and 3**, the porous composite block filter **20** can be substantially cylindrical in shape and can have an internal cavity or port **22**. The filter **20** also has an internal surface **21a** and an external surface **21b**. External surface area of the filter **20** is the area of the cylindrical surface formed by external surface **21b**. The filter **20** has an outside diameter **21c** and a length **21d**. Wall thickness **21e** is the perpendicular distance between the internal surface **21a** and the external surface **21b**. Block filters can also have other shapes, such as sheets, solids, cubes, parallelepipeds, etc.

[0065] The wall thickness **21e** and the external surface **21b** area of the carbon block filter can influence the flow rate of water through the filter. Good flow rates and effective contaminant removal can be achieved when the external surface **21b** area is between approximately 9 and 46 in². In other arrangements, the external surface area can be in the range of approximately 18 to 30 in². In one embodiment, the

wall thickness **21e** is in the range of approximately 0.25 to 0.75 in. In other arrangements, the wall thickness **21e** is approximately 0.35 to 0.60 in. The filter block **20** can have an outside diameter between about 2.0 and 4.0 in., a length between about 1.0 and 3.0 in. and a wall thickness between about 0.25 and 0.75 in.

Filter Sheets

[0066] FIGS. 4, 5 and 6, show examples of how filter sheets can be used with a porous composite carbon block. In FIG. 4, a filter sheet **24** has been applied to the internal surface **21a** of the block **20**. In FIG. 5, a filter sheet **24** has been applied to the external surface **21b** of the block **20**. In FIG. 6, a filter sheet **24** has been applied to both the internal surface **21a** and the external surface **21b** of the block **20**. The filter sheet **24** can enhance the performance and extend the life of the block filter **29**. In one embodiment, for example, the filter sheet **24** is a non-woven material with a 1.0 μm pore size disposed on the internal and/or external surface of filter block to facilitate the removal of microbiological cysts, such as Giardia and Cryptosporidium. In another embodiment, the non-woven material is disposed on the outside surface of the filter block. The non-woven material can capture particles in the range of approximately 5-1.5 μm , thus preventing particles in this size range from clogging the internal porous structure of the carbon block. Use of woven and non-woven filter sheets on filter block surfaces can result in extended filter life. Non-woven materials used in conjunction with filter blocks have been disclosed in U.S. Pat. No. 5,980,743, which is included by reference herein.

[0067] The filter sheet can include a woven or non-woven sheet material. As used herein, the term "nonwoven sheet" means a web or fabric having a structure of individual fibers or threads which are interlaid, but not in an identifiable manner as in a knitted or woven fabric. Nonwoven sheets can be prepared by methods that are well known to those having ordinary skill in the art. Examples of such processes include meltblowing, coforming, spinbonding, carding and bonding, air laying, and wet laying.

[0068] The filter sheet can also include a nonwoven charge-modified material. As will be appreciated by one having ordinary skill in the art, a nonwoven charge-modified microfiber glass web can be prepared from a fibrous web that incorporates glass fibers having a cationically charged coating thereon. Generally, such microfibers would contain glass fibers having a diameter of about 10 μm or less. The coating typically includes a functionalized cationic polymer that has been crosslinked by heat, i.e., the functionalized cationic polymer has been crosslinked by heat after being coated onto the glass fibers. The coating can also contain a metal oxide or hydroxide.

[0069] A fibrous filter can be prepared by a method that includes the steps of providing a fibrous filter having glass fibers, passing a solution of a functionalized cationic polymer crosslinkable by heat through the fibrous filter under conditions sufficient to substantially coat the fibers with the functionalized cationic polymer, and treating the resulting coated fibrous filter with heat at a temperature and for a time sufficient to crosslink the functionalized cationic polymer present on the glass fibers. The functionalized cationic polymer can include an epichlorohydrin-functionalized polyamine or an epichlorohydrin-functionalized polyamido-amine.

[0070] When used as a filter medium, the charge-modified microfiber glass material can contain at least about 50 wt % of glass fibers, based on the weight of all fibers present in the filter media. In some embodiments, approximately 100% of the fibers contain glass fibers. When other fibers are present, however, they generally contain cellulosic fibers, i.e., fibers prepared from synthetic thermoplastic polymers, or mixtures thereof.

[0071] As indicated above, the terms "cationically charged," in reference to a coating on a glass fiber, and "cationic," in reference to the functionalized polymer, mean having a plurality of positively charged groups in the respective coating or polymer. Thus, the terms "cationically charged" and "positively charged" are deemed synonymous. Such positively charged groups include, but are not limited to, a plurality of quaternary ammonium groups.

[0072] The term "functionalized" means having a plurality of functional groups, other than the cationic groups, which are capable of crosslinking when subjected to heat. Examples of such functional groups include epoxy, ethylenimino, and episulfido. These functional groups readily react with other groups typically present in the cationic polymer. The "other groups" typically have at least one reactive hydrogen atom and are exemplified by amino, hydroxy, and thiol groups. As will be appreciated by one having ordinary skill in the art, the reaction of a functional group with another group often generates still other groups which are capable of reacting with functional groups. By way of example, the reaction of an epoxy group with an amino group results in the formation of a P-hydroxyamino group.

[0073] Thus, the term "functionalized cationic polymer" is meant to include any polymer which contains a plurality of positively charged groups and a plurality of other functional groups that are capable of being crosslinked by the application of heat. Particularly useful examples of such polymers are epichlorohydrin-functionalized polyamines and epichlorohydrin-functionalized polyamido-amines. Other suitable materials include cationically modified starches.

[0074] A nonwoven, charge-modified, meltblown material can contain hydrophobic polymer fibers, amphiphilic macromolecules adsorbed onto at least a portion of the surfaces of the hydrophobic polymer fibers, or a crosslinkable, functionalized cationic polymer associated with at least a portion of the amphiphilic macromolecules, in which the functionalized cationic polymer has been crosslinked. The crosslinking can be achieved through the use of a chemical crosslinking agent or by the application of heat.

[0075] Amphiphilic macromolecules can include one or more of the following types: proteins, poly(vinyl alcohol), monosaccharides, disaccharides, polysaccharides, polyhydroxy compounds, polyamines, polylactones, and the like. In some arrangements, the amphiphilic macromolecules contain amphiphilic protein macromolecules, such as globular protein or random coil protein macromolecules. For example, in one embodiment of the invention, the amphiphilic protein macromolecules contain milk protein macromolecules.

[0076] Functionalized cationic polymers can contain a polymer that contains a plurality of positively charged groups and a plurality of other functional groups that are

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capable of being crosslinked by, for example, chemical crosslinking agents or the application of heat. Particularly useful examples of such polymers are epichlorohydrin-functionalized polyamines and epichlorohydrin-functionalized polyamido-amines. Other suitable materials include cationically modified starches.

[0077] Nonwoven charge-modified meltblown materials can be prepared by a method that involves providing a fibrous meltblown filter media having hydrophobic polymer fibers, passing a solution containing amphiphilic macromolecules through the fibrous filter under shear stress conditions so that at least a portion of the amphiphilic macromolecules are adsorbed onto at least some of the hydrophobic polymer fibers to give an amphiphilic macromolecule-coated fibrous web, passing a solution of a crosslinkable, functionalized cationic polymer through the amphiphilic macromolecule-coated fibrous web under conditions sufficient to incorporate the functionalized cationic polymer onto at least a portion of the amphiphilic macromolecules to give a functionalized cationic polymer-coated fibrous web in which the functionalized cationic polymer is associated with at least a portion of the amphiphilic macromolecules, and treating the resulting coated fibrous filter with a chemical crosslinking agent or heat. The coated fibrous filter can be treated with heat at a temperature and for a time sufficient to crosslink the functionalized cationic polymer.

Processing

[0078] A carbon block filter can be manufactured using conventional manufacturing techniques and apparatus. In one embodiment, the binder, carbon granules, and other actives are mixed uniformly to form a substantially homogeneous blend. The blend is then fed into a conventional cylindrical mold that has an upwardly projecting central dowel and heated to a temperature in the range of approximately 175-205° C. Pressure of less than 100 psi is applied to the blend during cooling. After cooling, the resulting porous composite carbon block is removed from the mold and trimmed, if necessary.

[0079] As noted above, in the processing of the carbon block, compression can be applied in order to achieve a more consistent and stronger carbon block than can be achieved using a sintering process as commonly practiced in the porous plastics industry. Compression can facilitate good contact between powdered or granular media and binder particles by pressing the powdered media into the binder. Compression can also prevent cracking and shrinkage of the carbon block while the filter is cooling in the mold. Thus, in one embodiment of the invention, a compression that reduces the fill height of the mold in the range of approximately 0%-30% is employed. In some arrangements, the compression reduces the fill height of the mold in the range of approximately 5-20%. In another arrangement no compression is applied.

Filter Cartridge/Filter Assemblies

[0080] Cylindrical filters as illustrated in FIGS. 2-6 can be employed in most, if not all, gravity-flow filtration cartridges adapted to receive same. FIG. 7 is a schematic cross section of a filter housing or cartridge 10 that contains a porous composite carbon block filter 20, according to an embodiment of the invention. The cartridge includes a cover 12 and a cup 14. The cover 12 can be attached to the cup 14 after

the filter 20 is placed inside the cup 14. Within the interior space of the cartridge 10 there is an outer space 15 outside the porous composite carbon block 20 and an inner space 22 within the bore of the porous composite carbon block 20. The cover 12 includes a plurality of entrance openings 17a near the center of the cover 12. The entrance openings 17a are adapted to allow water to enter into the inner space 22. The bottom 16 of the cup 14 includes a plurality of exit openings 18a. The exit openings 18a are adapted to allow water to exit from the outer space 15 and/or the porous composite carbon block 20.

[0081] FIG. 8 is a top view of the cover 12 of the filter cartridge 10 of FIG. 7, showing an exemplary embodiment of the invention. In this example, the entrance openings 17a are shown grouped near the center of the cover 12. Although the entrance openings 17a are shown as round holes arranged in a square array, it will be appreciated that other opening shapes, such as slots or slits and other arrangements of the openings, can be employed.

[0082] FIG. 9 is a bottom view of the cup 14 of the filter cartridge 10 of FIG. 7, showing an exemplary embodiment of the invention. In this arrangement, the exit openings are distributed in a circle concentric to an outer edge 19 of the cup bottom 16. Although the exit openings 18a are shown as round holes, it will be appreciated that other shapes, such as slots or slits, can be employed.

[0083] FIG. 10 is a schematic cross section showing a water flow path through the filter cartridge 10 and the carbon block filter 20. When the cap 12 is exposed to a body or flow of source water W, the source water W flows into and through the entrance openings 17a in the cap 12, and enters into the inner space 22 of the filter 20. The water W then flows through an interior wall 21a of the filter 20, out an exterior wall 21b of the filter 20, and into the outer space 15. In passing through the filter 20, the source water W becomes purified water W'. The purified water W' exits the filter cartridge 10 through the exit openings 18a.

[0084] FIG. 11 is a schematic cross section of a filter housing or cartridge 30 that contains a porous composite carbon block filter 20, according to another embodiment of the invention. The cartridge includes a cover 32 and a cup 34. The cover 32 can be attached to the cup 34 after the filter 20 is placed inside the cup 34. Within the interior space of the cartridge 30 there is an outer space 35 outside the porous composite carbon block 20 and an inner space 22 within the bore of the porous composite carbon block 20. The cover 32 includes a plurality of entrance openings 17b near the periphery of the cover 32. The entrance openings 17b are adapted to allow water to enter into the inner space 22. The bottom 36 of the cup 34 includes a plurality of exit openings 18b. The exit openings 18b are adapted to allow water to exit from the inner space 22 and/or the porous composite carbon block 20.

[0085] FIG. 12 is a top view of the cover 32 of the filter cartridge 30 of FIG. 11, showing an exemplary embodiment of the invention. In this arrangement, the entrance openings are distributed in a circle concentric with an outer edge 38 of the cover 32. Although the entrance openings 17b are shown as round holes arranged in a square array, it will be appreciated that other opening shapes, such as slots or slits and other arrangements of the openings, can be employed.

[0086] FIG. 13 is a bottom view of the cup 34 of the filter cartridge 30 of FIG. 11, showing an exemplary embodiment

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of the invention. In this example, the exit openings **18b** are shown as grouped near the center of the cup bottom **36**. Although the exit openings **18b** are shown as round holes, it will be appreciated that other shapes, such as slots or slits, can be employed.

[0087] FIG. 14 is a schematic cross section showing a water flow path through the filter cartridge **30** and the carbon block filter **20**. When the cap **32** is exposed to a body or flow of source water **W**, the source water **W** flows into and through the entrance openings **17b** in the cap **32** and enters into the inner space **22** of the filter **20**. The water **W** then flows through an exterior wall **21b** of the filter **20**, out an interior wall **21a** of the filter **20**, and into the inner space **22**. In passing through the filter **20**, the source water **W** becomes purified water **W'**. The purified water **W'** exits the filter cartridge **30** through the exit openings **18b**.

EXAMPLES

[0088] Embodiments of the present invention are further illustrated by the following examples. The examples are for illustrative purposes only and thus should not be construed as limitations in any way.

[0089] All scientific and technical terms employed in the examples have the same meanings as understood by one with ordinary skill in the art. Unless specified otherwise, all component or composition percentages are "by weight," e.g., 30 wt %.

Example 1

[0090] Two carbon block filters comprising approximately 80 wt % 80×200 mesh activated carbon (i.e., coconut shell carbon) and approximately 20 wt % binder were formed to investigate the water absorption characteristics of different binders. In filter #1, the binder was EVA. In filter #2, the binder was VHMWPE.

[0091] The degree to which carbon was available in each case to absorb impurities is indicated in the column labeled "percent available carbon." This was determined by comparing the iodine number for the raw carbon to the iodine number for the bound carbon.

[0092] As will be appreciated by one having skill in the art, the iodine number is a number expressing the quantity of iodine absorbed by a substance. Referring now to Table I, the fourth column expresses the iodine number for the raw carbon. The fifth column expresses the iodine number for the carbon in its bound form, i.e., in a filter block. In each case, the filter block was first produced in accordance with the process described above, and then a portion thereof was ground up for purposes of determining its iodine number.

[0093] Conventional sodium thiosulfate titration techniques were used to determine the iodine number in each case. The percentage of available carbon is the bound carbon iodine number divided by the raw carbon iodine number multiplied by 100.

TABLE I

Filter Ref.	Carbon (C)	Iodine Binder	Iodine No. of raw C	No. of block	Available C	Readily absorbs water?
#1	~80 wt %	~20 wt % EVA	1016	633	62.3%	No
#2	~80 wt %	~20 wt % VHMWPE	1016	860	84.6%	Yes

[0094] As shown in Table I, the percentage of available carbon is significantly greater in filter #2 where the binder was a very high molecular weight, low melt index polymer. The noted results thus indicate that the use of a very high molecular weight, low melt index polymer can maximize the water absorptivity of carbon block filters employing same.

Example 2

[0095] As is well known, a common measure of the absorbency of a material is called the "strike-through" value. The "strike-through" values are commonly employed in the absorbent article industry (e.g. diapers) to determine how fast a material absorbs water. Strike-through values were thus employed in the instant example to quantify the "wettability" of the carbon block filters. The method employed was as follows: a 1.0 in. internal diameter pipe section was glued to the surfaces of several carbon block filters so that approximately 0.785 in² of the block surface was exposed in the bottom of the pipe. A set quantity of water (i.e., 5.0 ml) was then introduced rapidly into the pipe section. Simultaneously with the introduction of the water, a timer was started. When the carbon block absorbed all the water, the timer was stopped and the absorption time recorded. The time to absorb the 5.0 ml of water was deemed the "strike-through" value for the respective carbon block filter.

[0096] Referring now to Table II, there is shown the strike-through data for several different carbon block filters.

TABLE II

Filter Ref.	Carbon (Waterlink coconut)	Binder	Zeolite	Comp.	Strike-Through (seconds)
#3	~65 wt % 80 × 200 mesh	~20 wt % VHMWPE	~15 wt %	10%	200
#4	~65 wt % 80 × 200 mesh	~20 wt % VHMWPE	~15 wt %	20%	160
#5	~65 wt % 80 × 200 mesh	~20 wt % VHMWPE	~15 wt %	30%	229
#6	~65 wt % 80 × 325 mesh	~20 wt % VHMWPE	~15 wt %	10%	57
#7	~65 wt % 80 × 325 mesh	~20 wt % VHMWPE	~15 wt %	20%	74
#8	~65 wt % 80 × 325 mesh	~20 wt % EVA	~15 wt %	20%	>2000

[0097] As reflected in the data set forth in Table II, filter #3, having the 80×200 mesh activated carbon, had a significantly higher strike-through value (~200 sec) as compared to filter #6, having a 80×325 mesh carbon. Filter #6 was thus deemed more "wetttable" than filter # 3.

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[0098] The strike-through value for filter #8, having an EVA binder, was also significantly greater than filters #3-#7, which have the VHMWPE binder. Filters #3-#7 were thus more wettable than filter #8.

[0099] The noted strike-through data further indicate that carbon block filters having fine carbon particle sizes and subjected to low compression exhibit greater wettability than those that have a more coarse carbon particle size and higher compression. Further, carbon block filters having high molecular weight binders, such as VHMWPE, provide significantly greater wettability as compared to an EVA binder.

[0100] It should be noted that filters that do not absorb water readily (e.g., filter #8) can still provide the benefits of fast flow and high contaminant reduction. In order to get such a filter to absorb water and begin flowing, initially water can be forced through the carbon block under pressures of 1 to 10 psi to wet the internal surfaces of the block. After the pressure conditioning step, the filters can flow just as fast as filters that have a low "strike-through" value. The noted conditioning step can be performed at the manufacturing facility and the filter sealed into a water tight bag or it can be performed by the consumer with a special adapter to connect the filter to a standard household faucet.

Example 3

[0101] The porosity of the carbon block filter is also critical in the performance and flow rate of the carbon block filters. The porosity of the finished carbon block is determined mainly by the particle sizes of the raw materials and by the amount of compression exerted on the block during the manufacturing process. As discussed below, smaller particles and higher compression can each result in lower porosity.

[0102] In order to investigate the porosity of the carbon block filters, carbon block filters of approximately 65 wt % activated carbon, 20 wt % EVA or VHMWPE binders and 15 wt % zeolite were prepared in accordance with procedures described herein.

[0103] Referring to Table III, porosity data for the noted filters are shown. The median pore diameter was determined by mercury porosimetry.

TABLE III

Filter Ref.	Carbon	Binder	Zeolite	Comp.	Vol. Median Pore Dia. (μm)	Filter Flow Rate (liter/min)
#9	~65 wt % 80 x 200 mesh	~20 wt % EVA	~15 wt %	20%	45.39	0.6
#10	~65 wt % 80 x 325 mesh	~20 wt % EVA	~15 wt %	20%	12.04	0.13
#11	~65 wt. % 80 x 200 mesh	~20 wt % VHMWPE	~15 wt %	20%	26.00	0.70
#12	~65 wt. % 80 x 325 mesh	~20 wt. % VHMWPE	~15 wt. %	20%	9.01	0.21

[0104] The porosity data indicate that, for a given binder, the larger the volume median pore diameter, the higher the resulting flow rate of the filter. It should be noted that filter

#11 had a higher flow rate than filter #9 and filter #12 had a higher flow rate than filter #10. These respective filter sets had identical filter formulations and compression but different binder types. Therefore, it can reasonably be concluded that higher flow rates can be achieved with a VHMWPE binder than with an EVA binder.

[0105] Furthermore, filters #11 and #12 had smaller volume median pore diameters than filters #9 and #10, respectively. However, the flow rates of filters #11 and #12 were still higher than #9 and #10, respectively.

[0106] Thus, a balance between volume median pore diameter and binder can (and should) be achieved to realize gravity flow rates between about 0.125 and 0.250 liters/minute.

Example 4

[0107] Three carbon block filters were formed in accordance with procedures described herein. Each filter had an outside diameter of 2.75 inches, a wall thickness of 0.42 inches, and a length of 3.0 in. The composition of each filter was ~65 wt % 80x200 mesh activated carbon, 20 wt % EVA binder and 15 wt % zeolite. The compression employed was approximately 20%.

[0108] Each carbon block filter was assembled into a filtration cartridge having an "inward flow" configuration, as shown in FIGS. 11-14. The filters were then tested for chlorine, lead—pH8.5 and VOC's to 300 liters in a carafe system in accordance with NSF standards 42 and 53. The results of the tests are set forth in Table IV.

TABLE IV

Filter Ref.	Head Pressure (psi)	Flow rate (liter/min.)	Cl reduction (%)	Pb reduction (%)	VOC reduction (%)
#13	0.15	0.65	>98%		
#14	0.15	1.1		99%	
#15	0.15	0.60			99%

[0109] The data set forth in Table IV shows that filters #13-#15 exhibited superior filtration performance, removing

virtually all of the chlorine, lead and VOC's, respectively, to 300 liter. The flow rates for the noted filters were also 3-5 times greater than conventional gravity flow filters.

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Example 5

[0110] Three similarly dimensioned gravity flow carbon block filters having about 68 wt % 80×200 mesh activated carbon, 22 wt % VHMWPE binder and 10 wt % zeolite were formed in accordance with procedures described herein.

[0111] Each carbon block filter was assembled into a filtration cartridge, as shown in FIGS. 11-14, having an “inward flow” configuration. The filters were then tested in a carafe system in accordance with NSF standards 42 and 53 for chlorine, lead pH8.5 and VOC’s to 300 liters. The results of the tests are set forth in Table V.

TABLE V

Filter Ref.	Head Pressure (psi)	Flow rate (liter/min)	Cl reduction (%)	Pb reduction (%)	VOC reduction (%)
#16	0.15	0.85	>98%	—	—
#17	0.15	0.90	—	99%	—
#18	0.15	0.95	—	—	99%

[0112] The results indicate that using a VHMWPE binder instead of an EVA binder yields higher average flow rates, while not affecting the contaminant removal capability of the filter.

Example 6

[0113] A similarly dimensioned gravity flow carbon block filter having the following composition was formed: about 68 wt % 80×200 mesh activated carbon, 22 wt % VHMWPE binder and 10 wt % zeolite.

[0114] The carbon block filter was initially assembled into a filtration cartridge having an “inward flow configuration,” as illustrated in FIGS. 11-14. The filter was then tested in a carafe system with an initial head pressure of 0.15 psi to assess the water flow rate.

[0115] The same carbon block filter was then assembled into a filtration cartridge having an “outward flow configuration,” as illustrated in FIGS. 7-10. The filter was then similarly tested in a carafe system with an initial head pressure of 0.15 psi. to assess the water flow rate.

[0116] The results of this comparative study are shown in Table VI.

TABLE VI

Cartridge Type	Flow Rate (liter/min)
Inward flow configuration	1.1
Outward flow configuration	0.85

[0117] The data clearly reflects that the flow rate of the inward flow configuration is significantly faster than the flow rate of the outward flow configuration.

[0118] Without departing from the spirit and scope of this invention, one of ordinary skill can make various changes and modifications to the invention to adapt it to various usages and conditions. As such, these changes and modifications are properly, equitably, and intended to be, within the full range of equivalence of the following claims.

1. A carbon block filter, comprising:

approximately 20-90 wt % activated carbon particles, the activated carbon particles having a mean particle size between approximately 90 and 220 μm ; and

approximately 5-50 wt % polymeric material binder, the binder material interspersed with the activated carbon particles.

2. The carbon block filter of claim 1, further comprising approximately 5-40 wt % additional active material.

3. The carbon block filter of claim 1, wherein the activated carbon particles comprise approximately 40-80 wt % of the carbon block filter.

4. The carbon block filter of claim 1, wherein the activated carbon particles have a mean particle size between approximately 150 and 200 μm .

5. The carbon block filter of claim 1, wherein the activated carbon particles have a mesh size of approximately 80×325 mesh.

6. The carbon block filter of claim 1, wherein the activated carbon particles have a mesh size of approximately 80×200 mesh.

7. The carbon block filter of claim 1, wherein the activated carbon particles have a mesh size of approximately 50×200 mesh.

8. The carbon block filter of claim 1, wherein the binder material comprises between approximately 20 and 35 wt % of the carbon block filter.

9. The carbon block filter of claim 1, wherein the binder material has a melt index <1 g/10 min at 190° C. and 15 kg load.

10. The carbon block filter of claim 1, wherein the binder material is selected from the group consisting of polyethylene homopolymers, modified polyethylene homopolymers, ethylene copolymers, ethylene-based ion-containing copolymers, fluoropolymers, nylon, polypropylene, and magnesium cements.

11. The carbon block filter of claim 1, wherein the binder material comprises particles having a mean particle size between approximately 20 and 150 μm .

12. The carbon block filter of claim 11, wherein the binder material comprises particles having a mean particle size between approximately 100 and 150 μm .

13. The carbon block filter of claim 1, wherein the activated carbon particles are impregnated with citric acid.

14. The carbon block filter of claim 1, wherein the activated carbon particles are impregnated with a hydroxide.

15. The carbon block filter of claim 14, wherein the hydroxide comprises sodium hydroxide.

16. The carbon block filter of claim 1, wherein the activated carbon particles are impregnated with a metal.

17. The carbon block filter of claim 1, wherein the activated carbon particles are impregnated with a metal oxide.

18. The carbon block filter of claim 1, wherein the activated carbon particles are impregnated with a metal ion.

19. The carbon block filter of claim 18, wherein the metal ion is selected from the group consisting of copper sulfate and copper chlorine.

20. The carbon block filter of claim 1, wherein the activated carbon particles are impregnated with a salt selected from the group consisting of zinc salt, potassium salt, sodium salt, silver salt and combinations thereof.

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21. The carbon block filter of claim 1, wherein the carbon block filter has an inside surface and an outside surface.

22. The carbon block filter of claim 21, further comprising a filter sheet, the filter sheet proximate a surface selected from the group consisting of the inside surface, the outside surface and combinations thereof.

23. The carbon block filter of claim 22, wherein the filter sheet comprises a non-woven web.

24. The carbon block filter of claim 23, wherein the non-woven web comprises a non-woven, charge-modified, microfiber glass web.

25. The carbon block filter of claim 23, wherein the non-woven web comprises a non-woven, charge-modified, melt blown web.

26. The carbon block filter of claim 1 further comprising a cartridge containing a cup portion and a cover portion, in which cartridge, the carbon block filter can be positioned.

27. A carbon block filter, comprising:

approximately 10-80 wt % activated carbon particles, the activated carbon particles having a mean particle size between 90 and 220 μm ;

approximately 10-50 wt % binder material; and

approximately 5-40 wt % additional active material.

28. The carbon block filter of claim 27, wherein the additional active material comprises between 10 and 30 wt % of the carbon block filter.

29. The carbon block filter of claim 27, wherein the additional active material comprises particles having a mean particle size between approximately 20 and 100 μm .

30. The carbon block filter of claim 27, wherein the active material comprises particles having a mean particle size between approximately 1 and 50 μm .

31. The carbon block filter of claim 27, wherein the active material comprises at least one material selected from the group consisting of zeolite particles, ceramic particles, alumina particles, and silica gel.

32. A gravity-flow system for treating water, comprising:

a container having a source water compartment than can hold source water and a treated water compartment that can hold treated water;

a cartridge in communication with both the source water compartment and the treated water compartment, the cartridge providing a path through which water can flow from the source water compartment to the treated water compartment; and

a carbon block filter disposed within the cartridge, the carbon block filter comprising:

approximately 20-90 wt % activated carbon particles, the activated carbon particles having a mean particle size between approximately 90 and 220 μm ; and

approximately 5-50 wt % polymeric material binder, the binder material interspersed with the activated carbon particles.

33. The system of claim 32 wherein the water has an average flow rate of at least 0.20 liters per minute through the system with a head pressure of between approximately 0.1 and 1.0 psi.

34. The system of claim 33 wherein the filter can remove at least 99.95% of particles greater than 3 μm in size from the source water until the water flow rate has been reduced by approximately 75% from an initial water flow rate.

35. The system of claim 32 wherein the filter can reduce lead concentration to no more than 10 ppb in 100 gallons of source water that has an initial lead concentration of 150 ppb.

36. The system of claim 32 wherein the filter can reduce chloroform concentration to no more than 80 ppb in 100 gallons of source water that has an initial chloroform concentration of 450 ppb.

* * * * *

ITC Inv. No. 337-TA-1294

RX-2601C

1 UNITED STATES INTERNATIONAL TRADE COMMISSION
2 WASHINGTON, D.C.

3
4 In the Matter of:)

5)

6) Investigation No.

7) 337-TA-1294

8 CERTAIN HIGH-PERFORMANCE)

9 GRAVITY-FED WATER FILTERS AND)

10 PRODUCTS CONTAINING THE SAME)

11)

12 _____)

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14
15 ***CONFIDENTIAL TRANSCRIPT***

16 CONFIDENTIAL BUSINESS INFORMATION

17 SUBJECT TO PROTECTIVE ORDER

18
19 VIDEOTAPED DEPOSITION OF ROGER REID

20 April 14, 2022

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29 Reported By: Amy E. Simmons, CSR, RPR, CRR, CR

RX-2601C.0001

Appx32186

1 VIDEOTAPED DEPOSITION OF ROGER REID

2
3 BE IT REMEMBERED that the videotaped deposition
4 of ROGER REID was taken by the Respondents at the Hyatt
5 Place Hotel located at 925 North Milwaukee Street, Boise
6 Idaho, before Veritext Legal Solutions, Amy E. Simmons,
7 Court Reporter and Notary Public in and for the County of
8 Ada, State of Idaho, on Thursday, the 14th day of April,
9 2022, commencing at the hour of 9:43 a.m. in the
10 above-entitled matter.

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42

1 designation of those documents as privileged. I
2 think we discussed yesterday ad nauseam that we
3 intended to bring those up, and we will keep the
4 deposition open unless something untoward happens.

5 But if we raise them, I expect
6 Mr. Ainsworth to raise the objection, and we'll
7 keep the deposition open pending resolution of
8 that.

9 MR. PEDERSEN: Right. Right. Right.
10 Because I expect to instruct him not to answer.

11 MR. LYONS: We'll get to it when it
12 happens, but our objection is noted that we
13 disagree with the designation.

14 MR. PEDERSEN: Right.

15

16 EXAMINATION

17 BY MR. LYONS:

18 Q. Sir, you thank you for coming in today.

19 Would you please state your name for the
20 record?

21 A. Roger Paul Reid.

22 Q. And your address?

23 A. Currently, 4102 Blue Heron, Marsing,
24 Idaho.

25 Q. And have you ever been deposed before?

1 goes beyond its structural capabilities to
2 withstand, the carbon block only needs to be
3 encapsulated into something that will hold the
4 pressure and seal each of the ends.

5 And usually a carbon block is radial
6 flow. I have seen end-to-end flows, but very,
7 very rarely, and only for specific applications.

8 Q. Can you think just generally of an
9 application of a carbon block with a radial
10 flow -- or I'm sorry, an end flow?

11 A. There were tests done on carbon blocks
12 that were -- we call them discs. And it would be,
13 for example, three-inch diameter by half-inch
14 thick. But it would have to be placed into a
15 housing that would keep water -- or force water to
16 go through the media rather than around it.

17 Q. Do you recall who made those discs, those
18 tests?

19 A. No.

20 Q. Has Omnipure ever made a sample filter,
21 gravity-flow filter, using granular carbon?

22 A. We have made -- state that question
23 again, please.

24 Q. Has Omnipure ever made a gravity-fed
25 water filter using granular carbon?

1 A. We make -- we have made in-line filters
2 that may have been used for a gravity application,
3 but not that necessarily we would have knowledge
4 of.

5 Q. When we talk about the work Omnipure's
6 done on filters for pitchers or carafes, have any
7 of those filters been granular carbon?

8 A. We have provided media to companies, and
9 those companies can place media inside of a
10 canister that would be gravity.

11 Q. What was the media called? Do you
12 recall?

13 A. The media that we call it -- we call it
14 Aquabond.

15 Q. Okay. And so that's a granular media?

16 A. It's a granular media. Can I describe
17 what Aquabond is?

18 Q. Please.

19 A. Okay. Aquabond is a granular media that
20 starts out as a powder, a carbon powder.
21 Carbon -- pardon me, binder material. And that
22 binder material is used to -- in a heat process to
23 grab onto and hold the powdered carbon and create
24 a granular media by combining binder and powdered
25 carbon.

1 Other materials can also be added in as
2 well. We can add a powdered lead sorbent in and
3 make a three-component product. So basically
4 Aquabond is a granular material that's been
5 processed from powder.

6 Q. So does that make -- the particles, then,
7 are each bigger?

8 A. The particles are bigger. And the reason
9 for doing that is to decrease pressure drops
10 against the water flow that you're trying to pass
11 through it.

12 Q. What's pressure drop?

13 A. Pressure drop is if you have a
14 filter -- and I'll go back to a granular filter.
15 The original Omnipure 6-inch in-line filter would
16 have a fitting on one end. It would have a
17 fitting on the opposite end. It would be
18 contained with a fabric media on each end, which
19 would keep the granular carbon in the center from
20 coming out. Water would pass from one side to the
21 other side.

22 If you passed 60 psi of -- 60 psi means
23 pounds per square inch -- water pressure, which
24 you might find in a typical house, through the
25 filter. It would take a pressure drop of about 10

1 psi to get it out the other side.

2 So if you were to measure pounds per

3 square inch, 60 pounds per square inch on the

4 inlet side, you might get 40 or 50 psi on the

5 output side. So you're going to have, for

6 example, a 10 psi pressure drop. The larger the

7 media that you have, the less pressure drop that

8 you have.

9 So if you were to go take an in-line

10 filter and use a 12 by 40 mesh carbon, which is on

11 the larger size, you would have a less pressure

12 drop. You might have a 10 psi pressure drop.

13 If you were to go to a 20 by 50 mesh or a

14 60 by 80 mesh, your pressure drop would increase

15 and you would have more of a 10 psi pressure drop.

16 It would be 10, 20 or more.

17 If you were to try to fill that same

18 in-line filter with 80x325 -- we call that

19 powder -- you wouldn't get water through it at

20 all. You would have almost 100 percent pressure

21 drop.

22 Q. Not going to that extreme, but is there a

23 reason that you want to reduce pressure drop

24 through a filter?

25 A. Well, if you -- it's a balance. You need

1 to be able to take a standard water supply of
2 pressure and you need to be able to get an
3 adequate, usable supply on the output side so
4 that -- you know, the smaller the media you use,
5 if it -- if you have a 30 psi or 40 psi pressure
6 drop, you could have your cup at the end of the
7 water filter and it may take you 10, 15, 20
8 minutes to fill your glass.

9 Well, that's not acceptable. You need to
10 have something to where the user can fill the
11 glass within a reasonable amount of time so that
12 you're not spending all day long at the water
13 cooler.

14 Q. Now, is there a benefit to have water
15 take longer to go through a filter?

16 A. There is. The longer the water spends in
17 the activated carbon, the better the removal rate
18 for whatever you're trying to remove. The better
19 the removal rate you're going to have.

20 Q. So that's where you're talking about the
21 balance is between the consumer --

22 A. Performance versus usability.

23 Q. Did Omnipure ever sell Aquabond to
24 Brita/Clorox?

25 A. Wow. I don't know.

1 Q. For the work between Omnipure and
2 Brita/Clorox, do you recall if you ever made
3 sample gravity filters that used granular carbon?

4 A. Again? One more time.

5 Q. Between Omnipure and Brita/Clorox, did
6 Omnipure ever create sample filters using granular
7 carbon?

8 A. I believe we did. I know we did with
9 Aquabond.

10 Q. But you're not sure if you sold Aquabond
11 to Brita/Clorox?

12 A. As far as a purchase, I don't know.

13 Q. Did Omnipure and Brita try to develop any
14 filters using Aquabond?

15 A. We gave them samples. They did their
16 sample tests, none of it which went to a saleable
17 product.

18 Q. Did Omnipure create sample filters using
19 carbon blocks for Brita/Clorox?

20 A. One more time.

21 Q. Did Omnipure create sample gravity-flow
22 filters using carbon blocks during their work with
23 Brita/Clorox?

24 A. I would say yes.

25 Q. Okay. So there were sample carbon block

1 filters that Omnipure made?

2 A. Now, let me clarify my response. A

3 carbon block, the gravity-flow carbon block, which

4 is the subject of the 141 patent, I consider that

5 a carbon block.

6 Q. Okay.

7 A. So yes, we provided many samples.

8 Q. Was there, like, a project name for any

9 of these that you recall?

10 A. Oh, yes.

11 Q. I have some documents I can pull up if

12 you don't recall off the top of your head.

13 A. Oh, if you give me a name, I'll verify

14 it. There's only one name.

15 Q. Do you recall a Maxtra?

16 A. Oh, that's a different name. Okay.

17 Maxtra is a different subject.

18 Q. Okay.

19 A. Maxtra, I believe, was a bowl or a

20 cup-shaped carbon block that was originally

21 designed to fit the German Brita Maxtra housing.

22 I believe the original was from Brita Germany,

23 which is not the same as Brita/Clorox.

24 Q. Now, I know Brita Germany has a

25 Maxtra --

1 A. GMBH.

2 Q. Has a Maxtra product. Is there -- what
3 makes it Maxtra?

4 A. I may be wrong on that.

5 Q. We can take a look through. This isn't a
6 memory test. If you don't recall, you can say you
7 don't recall.

8 There's a few different names in the
9 documents you provided, and I'm trying to figure
10 out what they are.

11 A. Okay.

12 Q. I guess let's start with -- can you go to
13 binder -- Exhibit 4, Binder 2.

14 A. I don't have a Tab 4, sir.

15 Q. Sorry. It's going to be PR-12. So it
16 will be the first tab --

17 A. First tab?

18 Q. Oh, second tab, sorry. And then if you
19 look at the bottom, the documents each have, like,
20 a PR number you'll see.

21 A. Okay. Through PR-52A.

22 Q. So --

23 MR. PEDERSEN: Jeff, this is Exhibit 4?

24 MR. LYONS: I think so. Yes.

25 MR. PEDERSEN: Got you. Thank you.

1 MR. LYONS: It's hard to keep track.

2 Q. (BY MR. LYONS) So PR-12.

3 A. 1-2, meaning 12?

4 Q. Yes. It's front and back.

5 A. PR-12?

6 Q. Yes. It's an email, appears to be from

7 Elizabeth Knipmeyer to you and other people.

8 Do you recognize this email?

9 A. Carbonado. Okay. I believe Carbonado

10 was the original name for the filter block of 141,

11 Patent 141.

12 Q. Okay. How would you describe generally

13 the filter block of the 141, shape, size? Like

14 how would Omnipure describe that block?

15 MR. AINSWORTH: Objection; vague, calls

16 for a legal conclusion.

17 Q. (BY MR. LYONS) You can answer unless

18 instructed not to.

19 A. Okay.

20 MR. PEDERSEN: Occasionally, attorneys

21 will object to the question. The interviewer can

22 continue after the objection gets on the record.

23 And the deponent -- that's you -- needs to answer

24 the question. It's just a flagging sort of

25 system.

1 THE WITNESS: Okay.

2 MR. PEDERSEN: Pardon me, Jeff. Could
3 you repeat that question?

4 Q. (BY MR. LYONS) Sure. How would Omnipure
5 describe the carbon block that is the subject of
6 the 141 patent?

7 MR. AINSWORTH: Same objection.

8 THE WITNESS: Okay. It would be a carbon
9 block about four inches tall, about 1 5/8 inches
10 diameter at the large end, which I would call the
11 open end.

12 It would be about one-and-a-quarter
13 inches tapered at the small end, and it would have
14 what you might like to think of as two pant legs.
15 So basically a pair of carbon blocks side by side,
16 but molded in one piece.

17 Q. (BY MR. LYONS) And how would water get
18 through that shape?

19 A. With a carbon block being sealed around
20 the outside edge of the large end in a carafe,
21 water would be -- water would have access to the
22 top open end of the carbon block with D-shaped
23 holes going down into the pant legs, where any
24 water pressure that was available would allow the
25 water to go in a radial pattern after that,

1 outward through the pant legs, and then collected
2 at the bottom. And it would normally fill the
3 pitcher itself.
4 It would be similar to taking a pair of
5 pants, tying off the bottom of each pant leg, and
6 filling it with water and holding it up. Well,
7 water is going to escape through the sides of the
8 pant legs and can be collected at the bottom. So
9 whatever goes through the material of the pant leg
10 would be considered filtered.

11 Q. That was very helpful for me. You make
12 it so I can understand it.

13 A. Okay.

14 Q. So the bottom is blocked, and the water
15 would push out through the pant legs. And that's
16 how it would come into contact with the activated
17 carbon to clean the water, essentially?

18 A. Correct.

19 Q. Was there a lead sorbent, as you used
20 that term before, in the Carbonado?

21 A. Yes.

22 Q. What's a lead sorbent?

23 A. A lead sorbent is a material -- for
24 example, Engelhard made an ATS material which I
25 believe was titanium-based. Selecto made a

1 material that was silica-based. And there was the
2 third material; I'm trying to remember the name of
3 it.

4 But there were three different materials
5 that are used as lead sorbents. When they come
6 into contact with water containing soluble lead,
7 the soluble lead will be attracted to this lead
8 sorbent. The lead sorbent will hang onto it and
9 not let it go through. It will absorb it.

10 Q. Does activated carbon remove any lead
11 from water?

12 A. Not to my knowledge, unless it's a
13 physical entrapment, physical filtration. But
14 there's no chemical -- I don't believe there is a
15 chemical attraction from the lead to the carbon.

16 Q. Do you know what ion exchange resin is?

17 A. Ion exchange resin is a plastic bead that
18 has either a positive or negative charge. And
19 with that positive or negative charge, it will
20 attract -- in the case of soft water or a water
21 softener, it will attract hard water particles and
22 attract it to the water softener resin beads and
23 keep the hard water from going through.

24 In the case of a lead sorbent, the lead
25 sorbent will be attracted to the resin bead. I

1 can't tell you whether it's a plus or minus charge
2 on the resin bead, but lead sorbent -- or pardon
3 me, soluble lead is attracted to either -- to a
4 resin bead of positive or negative charge.

5 Q. So are all, I guess, resin beads also
6 lead sorbents?

7 MR. AINSWORTH: Objection; vague, calls
8 for expert testimony.

9 THE WITNESS: I don't know -- I don't
10 know that all resin beads will attract lead
11 sorbents. You need to pick and choose which resin
12 bead you want.

13 Q. (BY MR. LYONS) Would the resin bead for
14 hard water -- you said a resin bead could deal
15 with hard water?

16 A. It can.

17 Q. So would that same resin bead also be a
18 lead sorbent?

19 MR. AINSWORTH: Objection; vague.

20 THE WITNESS: I don't know.

21 Q. (BY MR. LYONS) Okay. For the Carbonado
22 product -- you said that was the first name of the
23 product between Omnipure and Brita/Clorox?

24 A. Um-hmm.

25 Q. Did it change at all before the 141

1 patent?

2 MR. AINSWORTH: Objection; vague.

3 THE WITNESS: There was another name, I
4 believe, associated with it. Whether it was an
5 official name or a nickname, I'm not sure. It
6 will come to me. Give me some time.

7 Q. (BY MR. LYONS) Can we go to -- this same
8 binder, go to PR-3B. 3A, sorry. It should be an
9 email from Remy --

10 A. G-Force, thank you.

11 Q. What's the G-Force?

12 A. Okay. G-Force was the other name that we
13 referred to as the block that we were supplying to
14 Brita/Clorox for testing.

15 Q. Was that also a pant-shaped block?

16 A. Yes.

17 Q. Was there a difference between G-Force
18 and Carbonado?

19 A. Not that I can think of.

20 Q. Was there another block called a Presto?

21 A. Okay. Presto was a different project.
22 Presto was a carbon block that was somewhere in
23 the neighborhood of three-inch diameter with about
24 a half-inch wall, maybe three, four inches tall.
25 And it just had a much larger surface

1 area to allow gravity pressure in the size and
2 shape of a carafe that it would allow water to go
3 through it. It never went into production.

4 Q. Okay. Did the Maxtra -- do you recall if
5 that went into production?

6 A. No, I don't believe it did.

7 Q. Did the G-Force go into production?

8 A. Only as providing samples. It never went
9 into a commercial sale.

10 Q. Were the -- strike that.

11 Presto, was that also the subject of the
12 141 patent?

13 MR. AINSWORTH: Objection; vague, calls
14 for a legal opinion, legal conclusion.

15 THE WITNESS: The question is -- I don't
16 know.

17 Q. (BY MR. LYONS) Okay. And I guess the
18 same with the Maxtra. Was that design
19 incorporated into the 141 patent?

20 MR. AINSWORTH: Same objections.

21 THE WITNESS: I think a review of that
22 patent would tell me whether there are picture
23 shapes of it.

24 Q. (BY MR. LYONS) Okay. Yeah, okay. Good.
25 We can definitely do that.

1 Let me just -- I just want to get through
2 real quick -- just to focus on a little bit of the
3 Brita/Clorox relationship.

4 Do you recall designing any granular
5 filters for the 141 patent?

6 MR. AINSWORTH: Objection; vague.

7 THE WITNESS: As far as designing them?

8 Q. (BY MR. LYONS) Correct.

9 A. I would say no. Whether Clorox did any
10 testing with a granular Aquabond, I'm unaware.

11 Q. Okay. We'll go back to the figures in
12 the 141 patent. We'll talk more about that.

13 A. Yeah.

14 Q. So just to clear up, between Omnipure and
15 Brita, did you two ever release a commercial
16 product jointly?

17 MR. AINSWORTH: Objection; vague.

18 THE WITNESS: There are other products
19 that we manufacture that -- Clorox is a customer
20 of Omnipure. We sell to them. But not for a
21 gravity-flow.

22 Q. (BY MR. LYONS) Okay. So what are
23 the -- what are the products that you sell to
24 them?

25 A. We sell a carbon block that goes into an

1 end-of-tap filter. End-of-tap filter is a device
2 that screws onto the end of your faucet with a
3 valve on it. You turn your water on, you turn the
4 valve on, you get filtered water that comes
5 through it. But it's pressurized at whatever
6 household pressure is.

7 Q. Okay. Any other products?

8 A. That's it.

9 Q. Okay.

10 A. But I didn't want to answer that question
11 without at least saying yes, we do supply, and we
12 are a supplier to Clorox/Brita.

13 Q. Okay. But for the Carbonado, Maxtra,
14 G-Force pressure products, those were never
15 commercialized?

16 A. Never commercialized.

17 Q. Can you go to the second tab in this
18 folder. It's PR-55. I think it's in the last
19 tab. I'm sorry, Tab 3.

20 A. Tab 3?

21 Q. Yeah, sorry.

22 A. Okay. 55 what?

23 Q. 55 through 55b. So it starts with the
24 email on 55, and that's from you to Elizabeth
25 Knipmeyer.

1 A. I was actually looking for -- what was
2 the date of this request for change?

3 Q. If you go to the --

4 A. That's mostly out of curiosity myself.

5 Q. If you go to the bottom of the signature
6 page, on the bottom left it says Date:
7 November 15, 2021.

8 A. Okay. So recent.

9 Q. If you go back to page 4, this just makes
10 it easier. These are the corrections that were
11 requested and given in Table 5.

12 A. Okay.

13 Q. Do you see that the FRAP factor numbers
14 were changed?

15 A. Never having compared this, I haven't
16 seen a difference in numbers.

17 Q. So if you look at the FRAP factor column,
18 there's 58.6 in brackets and then 48.6 after.

19 A. I'm not sure where it's going to --

20 MR. AINSWORTH: Objection; lacks
21 foundation.

22 THE WITNESS: Oh, I see it here on the
23 right.

24 Q. (BY MR. LYONS) So the original, if you
25 turn back to the 141 patent Table 5, I can --

1 A. 141.

2 Q. If you just go one more page back there,
3 if you look at -- so for the PA3-5 --

4 A. Okay.

5 Q. Do you see the FRAP factor in the
6 original?

7 A. 58.6.

8 Q. Now, if you turn back, do you see where
9 58.6 is in brackets and there's a new number
10 after?

11 A. Yes, 48.6.

12 Q. So for all those changed values at the
13 end, did that take any of the filter
14 multiple-cores out of the claimed 350 or less FRAP
15 factor?

16 A. I don't know. Well, I don't know if it
17 does or not.

18 Q. Okay. So just looking at this document
19 now with the corrections, are any of them above
20 350?

21 MR. AINSWORTH: Objection; lacks
22 foundation.

23 THE WITNESS: Under mixed media, Brita
24 granular is over 350, to -- all of the mixed
25 medias are above; cylindrical blocks are under.

1 Q. (BY MR. LYONS) Both of them?

2 A. Both of them. Okay. It took a -- it
3 took Block No. 1, which under the original
4 formulation was 357.7, and changed it to 295.2,
5 which means it would be in violation of the
6 patent.

7 The one that started out at 308.2 was
8 under 350 to begin with and it went to 272.8,
9 which stays under 350.

10 Q. And you said before you weren't aware of
11 the certificate of correction before it happened?

12 A. Yes, which was not too long ago.

13 Q. And do you see the last one down there,
14 the Brita Granular went from 386.7 to 371.4.
15 Do you see that?

16 A. I see.

17 Q. That Claim 1 says a FRAP factor of about
18 350 or less.

19 A. What's the definition of about?

20 Q. I'm supposed to ask that.

21 A. Sorry.

22 Q. No, do you have any way to -- as an
23 inventor on this patent, do you have any way to
24 determine what about means in relation to that
25 term?

1 MR. AINSWORTH: Objection; calls for
2 expert testimony, calls for a legal conclusion.

3 THE WITNESS: I couldn't tell you.

4 Q. (BY MR. LYONS) Do you understand how the
5 FRAP calculation works?

6 A. Truthfully, no.

7 Q. Okay. So if I was to ask if you
8 increased variable V, you wouldn't know what that
9 would --

10 A. Nope. I have no idea.

11 Q. Okay. You didn't develop FRAP --

12 A. I didn't develop the formula. I never
13 tried to decipher it. It was something that was
14 working in the best interests of Brita/Clorox and
15 Omnipure at the time.

16 Q. Okay. Can you go to Tab 9. I think you
17 have to go back a little. So the substantive
18 document at the bottom is BRITALP-0000843.

19 A. Assignment?

20 Q. Yes.

21 A. Yes.

22 Q. Do you recognize that document?

23 A. Yes.

24 Q. Okay. And what is it?

25 A. It's an assignment of patent rights.

1 Q. To the 141 patent?

2 A. Yes, 141 patent.

3 Q. Okay. And is that your signature in the
4 signature line?

5 A. Yes.

6 Q. And the date, December 21, 2021?

7 A. Yes.

8 Q. Why did you first assign your inventor
9 rights to Omnipure in 2021?

10 MR. AINSWORTH: Objection --

11 THE WITNESS: The question was asked
12 wrong.

13 MR. AINSWORTH: Lacks foundation.

14 THE WITNESS: Why did I assign it to
15 Omnipure?

16 Q. (BY MR. LYONS) So here it says, Roger
17 Reid and Bruce Saaski, for good and valuable
18 consideration --

19 A. Okay. Okay. Because it was never done
20 in the beginning when the 141 patent was issued.

21 It was never completed correctly to start with.

22 So this is correcting that oversight. We had an
23 obligation to do what was right, and we did what

24 we intended to do at the time, so we followed
25 through on it.

1 Q. Okay. And so you said it just wasn't
2 done before?

3 A. It just wasn't done correctly when 141
4 was initially issued. So this is going back in
5 and dotting all the Is and crossing all the Ts to
6 make sure everything is correct.

7 Q. Okay. It says, good and valuable
8 consideration.

9 Do you know what the consideration was
10 for assigning that?

11 A. No, I don't.

12 Q. All right. Sorry to pull out the big
13 binder again, Exhibit 2, Binder 1. It should be
14 the second to last tab, so 13, I believe.

15 A. I'm working at it. Okay. What tab
16 number?

17 Q. 13, I believe. It should say PB-706 at
18 the top.

19 A. Yep.

20 Q. And then if you go to PB-728.

21 A. 728. Okay.

22 Q. Do you recognize that page?

23 A. Yes.

24 Q. Can you describe just generally what it
25 is.

1 A. It's a letter from Paul Walker to myself,
2 one signed original -- drawing my attention to
3 finding an enclosed one signed original of the
4 technology cross-license agreement between Brita
5 LP and Omnipure Filter Company.

6 Q. And that was March 10 of 2008?

7 A. Yes.

8 MR. PEDERSEN: Is this part of your
9 privilege claim?

10 MR. AINSWORTH: It is not.

11 MR. LYONS: No, I'll save that for the
12 end.

13 Q. (BY MR. LYONS) Who's Paul Walker?

14 A. Paul Walker, I believe, was involved in
15 the patent side for Clorox.

16 Q. He was not one of the scientists that you
17 worked with?

18 A. No, he was not one of the scientists, not
19 one of the hands-on people. He was a patent
20 attorney, I believe.

21 Q. Okay. So just bring that up. So the
22 date -- attached to that is -- on the next page
23 starting PB-729 is the patent cross-license
24 agreement.

25 Do you see that?

ITC Inv. No. 337-TA-1294

RX-2602C

1 UNITED STATES INTERNATIONAL TRADE COMMISSION
2 WASHINGTON, D.C.

3
4 In the Matter of:)

5)

6) Investigation No.

7) 337-TA-1294

8 CERTAIN HIGH-PERFORMANCE)

9 GRAVITY-FED WATER FILTERS AND)

10 PRODUCTS CONTAINING THE SAME)

11)

12 _____)

13
14
15 ***CONFIDENTIAL TRANSCRIPT***

16 CONFIDENTIAL BUSINESS INFORMATION

17 SUBJECT TO PROTECTIVE ORDER

18
19 VIDEOTAPED DEPOSITION OF BRUCE SAASKI

20 April 13, 2022

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29 Reported By: Amy E. Simmons, CSR, RPR, CRR, CR

1 VIDEOTAPED DEPOSITION OF BRUCE SAASKI

2
3 BE IT REMEMBERED that the videotaped deposition
4 of BRUCE SAASKI was taken by the Respondents at the Hyatt
5 Place Hotel located at 925 North Milwaukee Street, Boise
6 Idaho, before Veritext Legal Solutions, Amy E. Simmons,
7 Court Reporter and Notary Public in and for the County of
8 Ada, State of Idaho, on Wednesday, the 13th day of April,
9 2022, commencing at the hour of 10:06 a.m. in the
10 above-entitled matter.

11
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42

1 have --

2 MS. WOJCIECHOWSKA: I apologize. There's
3 one more. Ewa Wojciechowska, K&L Gates, on behalf
4 of Vestergaard.

5 MS. RUBSCHLAGER: Katherine Rubschlager
6 from Alston & Bird on behalf of Helen of Troy and
7 Kaz USA.

8 Adam Swain as well from Alston & Bird
9 will be joining us at some point today as well.

10 THE VIDEOGRAPHER: Will the court
11 reporter please swear the witness.

12

13 BRUCE SAASKI,
14 a witness having been first duly sworn to tell the
15 truth, the whole truth and nothing but the truth,
16 was examined and testified as follows:

17

18 EXAMINATION

19 BY MS. SIMMONS:

20 Q. Good morning, Mr. Saaski.

21 A. Good morning.

22 Q. My name is Cassandra Simmons. Can you
23 please state your name for the record.

24 A. My name is Bruce D. Saaski.

25 Q. And what's your address, Mr. Saaski?

1 Tab 4.

2 A. That's the Brita gravity-flow 141 patent.

3 Q. And you are a named inventor on this
4 patent, correct?

5 A. That's correct.

6 Q. Can you please describe your contribution
7 to this patent.

8 A. I was involved in some of the shape
9 design, formulations work, choosing raw materials,
10 particle size differentiation, and different raw
11 materials to try to achieve a gravity-flow carbon
12 block claim for particulate lead. I was involved
13 in making a lot of the hand samples, molding them,
14 formulating them, and reporting all the data.

15 Q. And what sort of data did you take?

16 A. We did mainly flow-rate data there. And
17 we did some dimensional data where we
18 measured -- if you want to have consistency and
19 dimensions. Because a problem with a lot of these
20 gravity-flow products, since they're not under a
21 lot of pressure when they're being formed, they
22 have a tendency to either shrink or distort.
23 So we were doing a lot of measurements to
24 make sure the wall thickness stayed the same.
25 Because if you have areas with thinner wall

1 thicknesses, you have preferential water flow and
2 potential premature breakthroughs. So we were
3 looking for those types of things.

4 Q. And when you talk about wall thickness,
5 are you talking about the carbon block or the
6 cartridge?

7 A. The carbon block wall. So it would be
8 kind of like these shaded-in sections here, would
9 be denoting the carbon block wall.

10 Q. And can you describe a little bit more
11 about the distortion.

12 A. What happens when you make something
13 under pressure, basically, you have a lot of
14 pressure. So you can form whatever your mold is.
15 You can fill that mold really good.
16 But when you're doing, like,
17 gravity-flow, you can't have a lot of compression
18 because you close down your porosity. The
19 porosity just means the open space between the
20 carbon particles and the binder. Because the
21 binder may be not melting all the way. Basically
22 you're just cinderizing the product.

23 So you need those void spaces for the
24 water to flow. So if you put a lot of
25 compression, you're going to close those down.

1 You're going to make them smaller. It very
2 difficult to flow under gravity then, whereas when
3 you have pressurized flow, you can flow water
4 through a much smaller void area because you have
5 pressure behind it.

6 When you have gravity-flow, you only have
7 the head pressure above so you need a certain open
8 porosity in the block.

9 So kind of like, you know, like a sponge,
10 has holes in it? So if you don't have enough
11 holes that are big enough for water to flow
12 through under gravity, it's not going to hardly
13 flow at all.

14 Q. Is this an issue that you also see in
15 granular filters?

16 A. Granular filters typically you don't see
17 it because you have so much void space between the
18 grains. So there is a lot more open area because
19 you're using much coarser particles. In other
20 words, we talk about mesh sizes. And that just
21 denotes basically the size of the particle.

22 So you have a set of U.S. standard
23 sieves, basically, that you sieve it to. So
24 you'll have a, like, 12-mesh, a 14-mesh, a
25 15-mesh, and so on. So the smaller number means

1 larger particles.
2 So typically in a granular device, you're
3 probably using somewhere by like 14x36 mesh, where
4 in a product like this, you're using, like, 80x325
5 mesh, so really, really small particles.
6 So you want a thin wall, but you don't
7 want to compress it. Because if we compress it,
8 then we can't get water to flow through it.
9 So what happens when you don't compress
10 all the way, you can have distortion. You want to
11 get just enough pressure to form the shape in the
12 mold. So in other words, if I have a mold, when I
13 pop that out, I want to have it look like what
14 that mold is on the interior. I don't want to
15 have, like, warps in the side wall or any of that
16 kind of stuff.

17 Q. Right. And so your work related to this
18 patent is only carbon block filters?

19 MR. AINSWORTH: Objection; vague, calls
20 for a legal conclusion.

21 THE WITNESS: Let me answer that -- it's
22 basically -- I think the answer, the basic answer
23 would be it basically falls around work to develop
24 in gravity-flow carbon block.

25 Q. (BY MS. SIMMONS) Did you produce any

1 granular carbon filters in relation to this
2 application?
3 MR. AINSWORTH: Objection; vague.
4 THE WITNESS: I don't recall any. I
5 mean, we may have benchmarked the original Brita
6 carafe just from a flow rate standpoint, but we
7 pretty much knew that data going in from other
8 prior work that we talked about.
9 But I don't recall us really spending any
10 time on -- the problem with doing particulate
11 lead, which this is more around, is granular
12 filters typically do not work. Because the
13 problem is your grains, the media, are too far
14 apart. You're relying on diffusion kinetics. So
15 you need a long time for that lead to diffuse.
16 And when you're talking about colloidal
17 lead or particulate lead, it typically doesn't
18 have a charge. So you can't pull it out with like
19 an ion exchange resin which has a charge on it.
20 So if I have something that's charged,
21 I'm trying to pull something out of the water
22 that's also charged, kind of like a magnet. I've
23 got to attract them. Well, the longer the
24 distance gets, the more time I need.
25 On gravity-flow, that's not good. That's

1 why you don't see a lot of gravity-flow granular
2 devices listed for lead reduction claims.
3 Q. I guess, would increasing the volume of
4 filter media help with that problem in a granular
5 filter?

6 A. If you made it larger, it could help.

7 Q. Okay. I guess we will take a look at
8 Claim 1 now. So that is on Column 34.

9 A. 34.

10 Q. Okay. So the -- will you just go through
11 the claim. I'm just trying to get an
12 understanding of, sort of, what parts, like,
13 where, you know, your contribution was to this
14 claim.

15 So we have a gravity-fed water filter.

16 Do you believe you contributed to that
17 part of this invention?

18 A. The gravity-flow water filter, correct,
19 yeah.

20 Q. The next part we have is A filter media
21 including at least activated carbon and a lead
22 scavenger.

23 Do you see that?

24 A. Yeah, and a lead scavenger, correct.

25 Q. Did you contribute to this part of the

1 claim?

2 A. The equation?

3 Q. No, just the filter media.

4 A. The filter media, yeah, we did.

5 Q. Okay.

6 A. Yeah, that was a collaboration, again,
7 amongst all of us.

8 Q. And then what is activated carbon?

9 A. Activated carbon, basically you can take
10 any organic substance -- typically we used coconut
11 shelling, coconut shells. You could use coconut
12 shells; you could use macadamia nuts; you could
13 use peach pits; you could use a number of
14 different things.
15 Coconut shells is one of the preferred
16 activated carbons in the water treatment industry
17 because it has a lot of micro pores, is very, very
18 good at removing small molecular weight compounds
19 like mult organic compounds. It's readily
20 available.

21 There are some sustainability things that
22 go along with it because it's a crop that
23 basically is regrown every year versus, like,
24 mining coal out of the ground which will take your
25 lifetime and many lifetimes after that to make

1 that again.
2 Coal-based carbons are typically fairly
3 dirty, have a lot of heavy metals in them, so you
4 need to acid wash them.
5 Coconut shells are pretty much the carbon
6 of choice now in the water treatment industry,
7 except for maybe some extraneous-type claims.
8 But you're basically just taking the
9 coconut shell and you char it in a low-oxygen
10 atmosphere. And then put it into a kiln, heat it
11 up to about 7- to 900 degrees Centigrade on a
12 low-oxygen atmosphere, and then it ejects steam to
13 form the pores. So that's activated carbon.

14 Q. That is a thorough description of
15 activated carbon.

16 You mentioned that activated carbon is,
17 like -- can filter contaminants.

18 A. Right.

19 Q. Can it filter lead?

20 A. There are some papers out that were
21 written a long time ago that show the ability to
22 sorb lead. And a lot of it has to do with the
23 activation and surface kinetics. But even though
24 it can really absorb lead, like I said, the
25 drinking water treatment standards, if you look at

1 the NSF standards, even though it removes some
2 lead, will never be able to get to the level that
3 we need in the effluent -- that means the water
4 coming out of the filter -- to where we'd ever be
5 able to pass that standard. You'd never be able
6 to certify a product.

7 When the standard used to be 50 parts per
8 billion of lead, there was a couple companies of
9 really large format carbon blocks that were able
10 to remove lead, but the capacities were really
11 low.

12 Once the standard went to 10 parts per
13 billion and now it's 5 parts per billion, it's
14 kind of like out of the realm. You'd have to have
15 a really exotic surface treatment to do that. I'm
16 not aware of any that are out there yet.

17 Q. And I guess the next element is a lead
18 scavenger.

19 What is a lead scavenger?

20 MR. AINSWORTH: Objection; calls for a
21 legal conclusion.

22 THE WITNESS: I can answer that or --

23 MR. PEDERSEN: Yeah.

24 Q. (BY MS. SIMMONS) Yeah.

25 A. Okay. Basically a lead sorbent in this